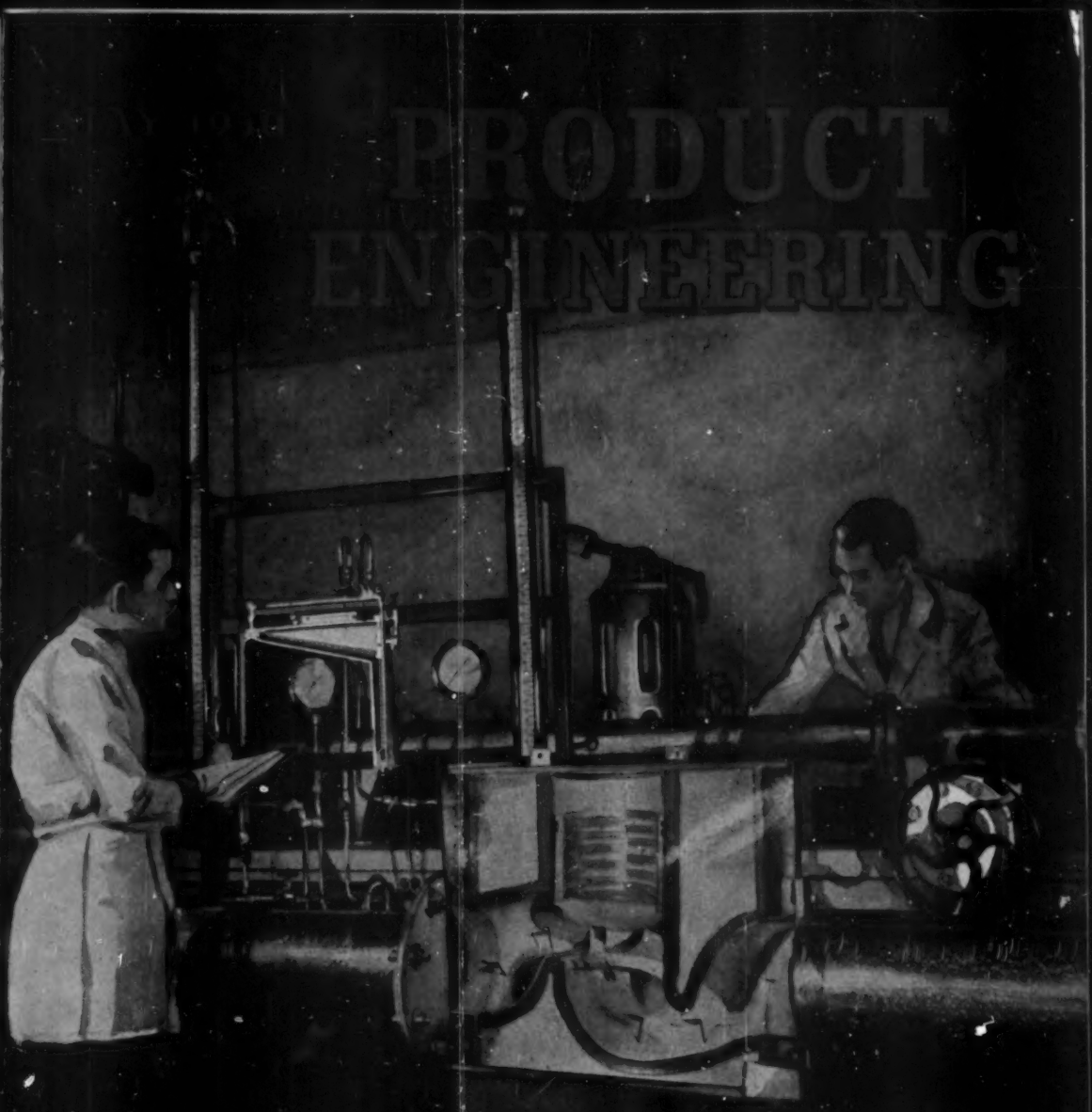
PRODUCT ENGINEERING



HALF-MODELS SIMPLIFY VALVE DESIGN

Maintain Operating Accuracy

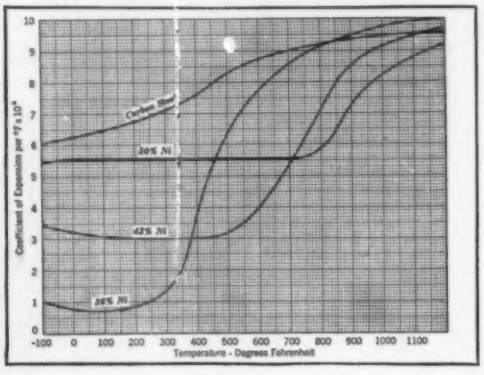
BY USING

Iron-Nickel Alloys

TO CONTROL THERMAL EXPANSION

Any desired coefficient of expansion, ranging from almost zero to a value greater than that of ordinary steel, may be obtained with the iron-nickel alloys. In addition, these alloys are strong, tough, ductile and possess a useful degree of corrosion resistance.

In wide use is a 36% nickel alloy... aptly named "Invar" because its dimensions remain almost *invariable* over the range of atmospheric temperature variations. However, as nickel content goes higher, expansion increases continuously. The chart, below, shows the thermal expansion characteristics of Invar and two other high nickel alloys, along with those of carbon steel for comparison.


Coefficient of Expansion per °F x 10⁶
Carbon Steel
50% Ni
42% Ni
36% Ni
-100 0 100 200 300 400 500 600 700 800 900 1000 1100
Temperature - Degrees Fahrenheit

EMBLEM OF INCO SERVICE TRADE MARK

The International Nickel Company, Inc.
Dept. PE, 67 Wall St., New York 5, N.Y.

Please send me further information about Iron-Nickel Alloys.

*Name*_____ *Title*_____

*Company*_____

*Address*_____

*City*_____ *State*_____

FABRICATION

Like all austenitic alloys, those of the iron-nickel system respond well to plastic deformation, either hot or cold. They may be welded by any of the commonly used methods, and users report their machining characteristics are very similar to those of other high nickel alloys such as Monel® and Inconel®. A special, free-cutting grade is available to meet exacting machining requirements.

APPLICATIONS

Where dimensional changes with temperature must be minimized, or where such changes must approximate those of other materials of relatively low expansivity, iron-nickel alloys... sometimes modified by other alloying elements... are almost universally used.

For example... in thermostatic bimetal strip, Invar serves as the low expansion side for use up to moderately elevated temperatures. At higher temperatures, the 42% nickel alloy is commonly used. For the high expansion side, special alloys, containing 15-25% nickel, are used extensively because they develop nearly double the expansivity of iron. Iron-nickel alloys are also widely used in glass-to-metal seals, where expansivity of the glass must be closely matched. The 42% nickel alloy, sometimes with added chromium, is used with soft glasses. Hard glasses call for nickel alloys containing added cobalt.

Scores of other iron-nickel alloy applications include bases for giant telescopes, surveyors' tapes, radio condensers, parts for textile machinery and for numerous precision instruments and devices.

Industrial fields of usefulness for the iron-nickel alloys are far from exhausted. These unique materials can be of incalculable value in improving instrumentation and process control, and in the design of new devices. They are available in various forms including wire, rod, strip, sheet, bars and tubing. Send coupon today for additional information on the properties of iron-nickel alloys... they may be the means of improving your products, equipment, or process.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

VOLUME 21

PRODUCT ENGINEERING

NUMBER 5

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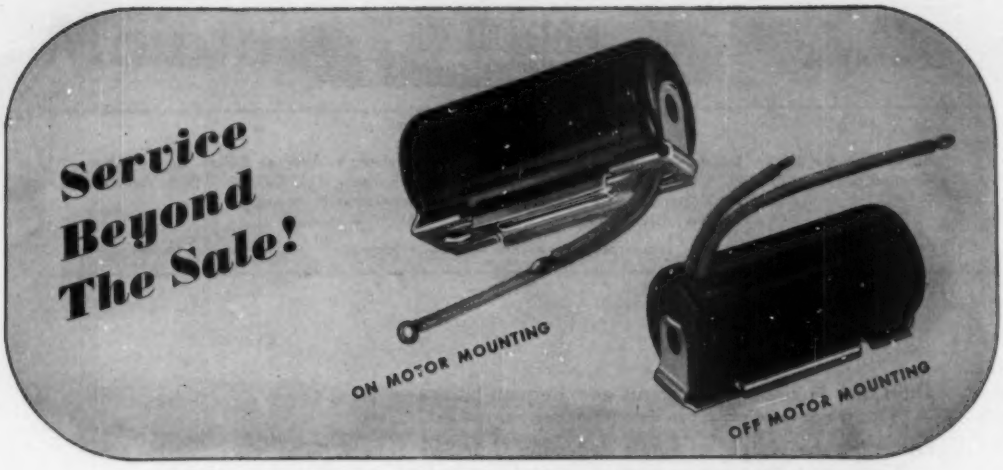

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Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

Metallic Materials

NEW STAINLESS STEEL composed of 17 Cr, 4 Ni and 4 Cu is easy to fabricate and harden. Soft-temper strip, sheet and plate is brought to full strength and hardness by heating to 1,400 F for 30 min, air cooling and then reheating to about 900 Fahrenheit.

NEW ELEMENTS are continuing to roll off the cyclotron assembly line in the University of California's Berkeley labs. Latest is Number 98, Californium, half-brother of Berkelium. (P.E., March 1950, p 3). Of little practical use, the trans-uranium element has a half-life of only 45 minutes.

WROUGHT STAINLESS resists highly concentrated sulphuric acid used in processing industries. Nominal composition is 29 Ni, 20 Cr, 3 Cu and 2 Mo. Mechanical properties are similar to those for 18-8. Uses include mixing tanks, heat exchangers, piping, pump shafts and rods.

PRINTED CIRCUITS used in small electrical equipment are now cheaper and simpler to produce. Copper ink, which takes the place of the silver conducting paste, can be deposited on a plastic base using conventional engraving and printing equipment.

HIGH-TEMPERATURE SHEET containing 50 Co, 20 Cr, 15 W and 10 Ni has a yield strength of 70,000 psi and an ultimate of 155,000 psi at 1,800 F. Alloy is readily formed by bending, stamping or drawing, is weldable and corrosion resistant.

MACHINABLE TUBING with properties of stainless steel is comparable to SAE 3120, 3145 and 4615 grades. Welded rounds and shapes up to 4½ in. OD are non-galling and applicable for screw machine parts, bearings, bushings, instrument and valve parts. Tubing is not recommended for cold working operations such as flaring and bending.

ZIRCONIUM, in combination with titanium, takes the brittleness out of permanent magnet alloys like Alnico V. Field of application for these materials can therefore expand because machinability is increased.

TUNGSTEN-IRIDIUM thermocouples appear to be the best performers at temperatures above 2,900 F. In neutral atmospheres, they have a high thermal emf, nearly linear calibration curve from 1,800 to 3,800 F, and a negligible room temperature emf which obviates cold-junction calibration.

Nonmetallic Materials

RESIN CEMENT for wood, paper, leather and ceramics is moisture resistant, has dielectric strength of 1,700 v per mil and does not distort below 200 F. Water-white compound has consistency of molasses.

JET ENGINES using thiophene-enriched hydrocarbon fuels are not prone to load up with soot. Combustion chambers stay clean and overall effectiveness of powerplant remains high. Thiophene, a coal tar derivative, can also be synthesized.

SILICONE-GLASS molding compound withstands heat to nearly 400 F, is both shock and arc resistant. Easy to mold, compound is already being used in circuit breakers and switch gear assemblies.

SANDWICH PANELS of end-grain balsa flanked by thin facings of high-strength aluminum combine many desirable design properties—excellent aerodynamic smoothness, high strength-weight ratio and minimum skin buckling.

LATEST ENTRY in the search for non-flammable hydraulic fluids is one that is claimed to be "fool-proof". This newcomer is nontoxic, non-corrosive to metallic parts and completely compatible with packings and seals used in hydraulic systems.

Continued on Page 5

WHY ARE CONIFLEX GEARS SUPERIOR?

Coniflex* gears, unlike ordinary straight bevels, are relieved at both ends of the teeth. Result: A "flexible" tooth bearing with allowable tolerances to facilitate assembly and provide superior operation.

Coniflex* gears can be cut in a large range of sizes. The two machines pictured, the Gleason No. 14 Straight Bevel Generator and the No. 24A Straight Bevel Generator, provide a means of cutting up to 35½".† CONIFLEX* gears, cut on these machines are long-lasting, smoother-operating gears free from the danger of concentration of load on the ends of the teeth.

Write for "Generated Coniflex Gears" for information on the many advantages of Coniflex gears.

†In some cases capacity may be increased. Submit prints for our recommendations.

*Reg. U. S. Pat. Off.

GLEASON Works
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Rochester 3, N. Y., U. S. A.

Builders of Bevel Gear Machinery for Over 85 Years

O-RINGS AND SEALS molded of a special synthetic rubber satisfy Specification AN-G-35 at -65 F. Tensile strength of compound is 1,340 psi; Shore "A" hardness, 88; elongation, 100 percent. Typical uses include seals for port connections on valves, cylinders and other accessories in high-pressure hydraulic systems.

HYDRAULIC oil for motors and pumps has viscosity of 90-100 SUS at 100 F and pour point of -25 F. Body, load-carrying and nonfoaming characteristics are stable from zero to 210 F. Compound satisfactorily meets Vickers specification for hydraulic oils.

Processes

ELECTROPOLISHING is being tried as a substitute for drawing in the production of wire having diameters as small as 0.00015 in. Wire becomes electrode in an electrolytic bath that polishes away the surface. More compact electronic equipment and supersensitive instruments are some of the likely end-products that will profit by this development.

HOT PRESSING of beryllium powder shows promise for relatively large simple, shapes suitable for machine-finished products. Tests indicate tensile strength is comparable to that for beryllium castings. Process outdoes cold press-sinter methods because compacts 12 in. in diameter and 4 in. thick are readily producible.

PROTECTION for rolled-gold plate produced by the Inter-Weld process (P.E., September 1949, p 5) is now provided in the form of a plastic film. Coating does not rupture during blanking and forming operations and protects the mirror finish from die and handling scratches. Plate can be any color gold on any metallic base, is more dense than electroplate.

SAND CASTINGS made by the Croning process have smooth surfaces and sharp edges. Tolerances can be held to 0.002 to 0.003 in. per in. A mixture of sand and pulverized phenolic resin forms a thin mold when poured over a heated metal pattern. Cores are made in same manner, except that mixture is blown into a split core box with jet of compressed air. Baking and curing times are short.

LONG FLANGED TUBES used in food processing machines are being die cast from aluminum instead of machined or spun from aluminum castings or sheet. Novel feature is use of long cores to form inside contours.

SINGLE-STROKE forming process results in sheet steel pressings of large proportions. As many as 144 tank heads 14½ in. in diameter and 24½ in. deep can be drawn from 12-gage steel blanks. Special dies do the trick by subjecting the blank to a double reverse draw.

NOVEL METHOD of preventing steel from corroding is to bond strips of aluminum foil on the surface. It's a two-step proposition—electrodeposit an iron coating and then heat steel to 850 F before applying the aluminum.

Components

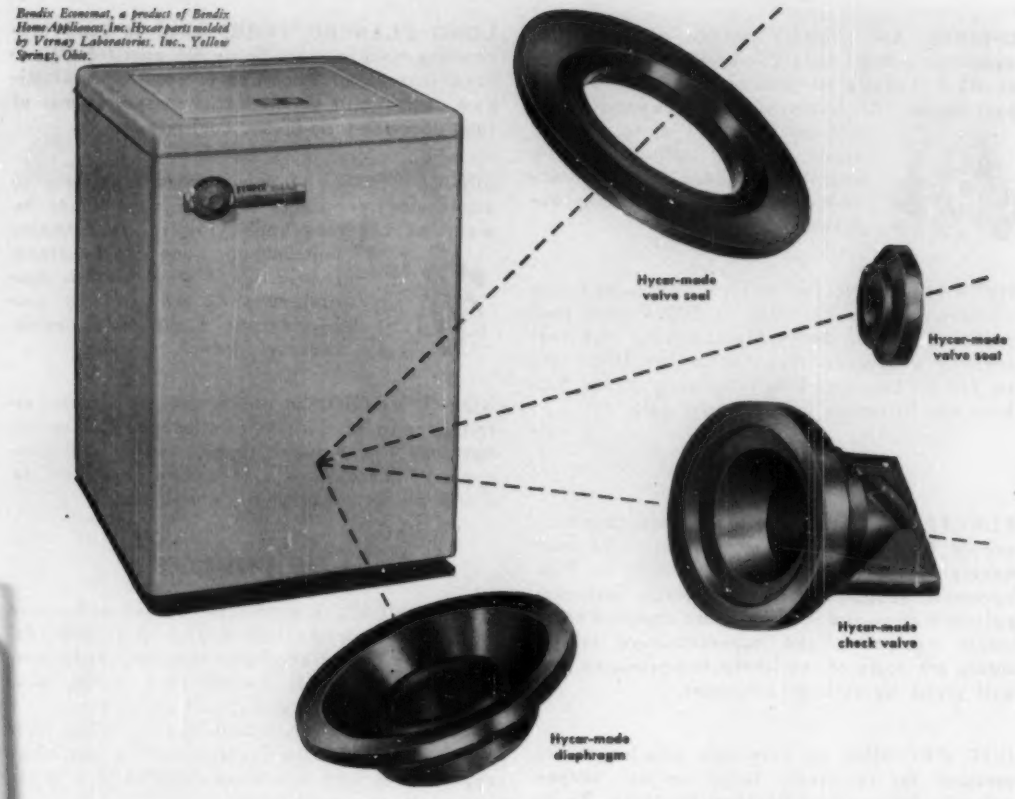
TORQUE UNIT for velocity servos and motor integrator systems has a 27.5 v 10,000 rpm (max) d-c motor-generator set and reduction gear assembly, all housed in a 1½-in. dia, 6-in. long aluminum tube Output torque is 6 oz-in., max output shaft speed is 250 rpm. Device can also be incorporated in position-type servos with the motor coupled to a separate follower mechanism.

POROUS BRONZE SHEETS are doing an efficient job of filtering in several applications. 18-ft strips 14 in. wide and ¼ in. thick control boundry-layer effects on airfoils, serve as pressure differential linings in wind tunnels and act as sweat-cooling surfaces through which liquids are pumped.

"TOOTHPASTE-TUBE" PUMP handles corrosive liquids and gases at a gallon-a-minute clip. Corrosive mixtures are squeezed through a plastic-lined rubber tube by a series of rollers mounted on the side of a revolving disk. As disk spins, rollers flatten tube against a semi-circular frame, causing liquid to move ahead.

TWO METAL CYLINDERS, one inside the other, appear to do a better job than disks in a new version of the magnetic-fluid clutch. Rectangular teeth on the clutch faces also add to the capacity of the 6- by 6-in. unit that will lift one ton 1,000 ft per minute.

Continued on Page 7



Bendix Economat, a product of Bendix Home Appliances, Inc. Hycar parts molded by Vernay Laboratories, Inc., Yellow Springs, Ohio.

Hycar helps put the *Squeeze* on washer costs!

THE engineers who designed the revolutionary new automatic washer pictured here came up with a hatfull of cost-saving, performance-improving features!

One of these is a flexible tub that "squeezes" water from clothes. Two more are a vacuum release and a check valve, made with Hycar American rubber. They control the water flow that rinses clothes. The entire principle of top draining and proper drying of the clothes is dependent upon the vacuum release valve operating without failure.

These Hycar parts are outstanding examples of precision engineering and molding. Hycar was chosen because the components must undergo no dimensional change while in operation, and must also possess low water absorption and high resistance to compression set. What's more, Hycar came through perfectly in laboratory tests with all types of alkalies, soaps, detergents, bleaches and washing compounds at water temperatures up to 200°F.

Hycar
Reg. U.S. Pat. Off.
American Rubber

Throughout, this unusual new washer shows ingenious use of materials and mechanisms that help reduce the cost to the manufacturer —and to the user.

What Hycar does here may give you ideas for cutting costs and improving the performance of your products—or your product designs. For versatile Hycar is used as a base material . . . as a plasticizer for polyvinyl resins . . . as a modifier for phenolic resins . . . as an adhesive base . . . as a latex for coating or impregnating. For further information and assistance, please write Department HL-3, B. F. Goodrich Chemical Company, Rose Bldg., Cleveland 15, Ohio.

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GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers

WEIGHT AND SPACE savings in radio and television sets, hearing aids, alarm systems and thermostats will be great when a new subminiature tube gets into production. About the size of a match head, the Fieldistor is shock resistant and requires very little current.

CIRCUIT BREAKER PLUG for the end of appliance cords has built-in overload time-delay switch. Bi-metal thermostat can be set for ratings from 2 to 10 amp on 125 v a-c lines. Two-prong assemblies have reset lever, 3-prong units have recessed button that must be pressed.

WIRE CABLES embedded in two adjacent plies under the tread of pneumatic tires bring about several benefits. Compared to standard constructions, new design is lighter in weight, more resistant to cuts and punctures, and has greater load-carrying capacity.

NICKEL-CLAD COPPER WIRE, both solid and stranded, in all commonly-used sizes may be the answer to many problems faced by designers of electronic devices, jet engines and heating appliances. High corrosion and heat resistance, strength and an electrical conductivity approximately 70 percent that of pure copper are the chief advantages.

Testing

DOLLAR SAVING TIPSHEETS packed with answers to the question "How do I go about redesigning a product for lower costs?" will be featured in the June PRODUCT ENGINEERING. Mechanical transmissions and parts; production processes; materials; hydraulic, pneumatic and electrical components are just a few of the subjects to be presented.

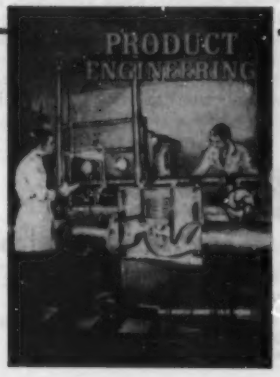
EXTENSIVE TESTS are being conducted with special presses and various alloys for producing cold-extruded steel parts. Although procedures for press stroke and pressure are not as yet perfected, it is known that low-carbon, low manganese steels can be successfully formed by this method. Main advantages are low scrap rates, smooth and accurate finish and high strength.

"ENVELOPE JIGGING" of airframes is being tested in England. Outside skin of sub-assembly structures is shaped and located on special jogs. Ribs and other internal members are then added. Objective is to preserve details of the original design. Inaccuracies that occur during assembly therefore grow inward.

STRAIN GAGE RECORDER plots automatically 5- by 3-in. load-strain graphs for 100 or more test points. A stylus travels horizontally along a test panel and, through electronic circuits, balances a series of Wheatstone bridges. Behavior of every gage point can thus be individually studied while a test is in progress.

WHITE MAGNETIC FLUID offers high degree of contrast when checking dark-colored ferrous parts for flaws. Whiteness of standard paraffin-magnetic oxide mixtures is obtained by adding powdered aluminum.

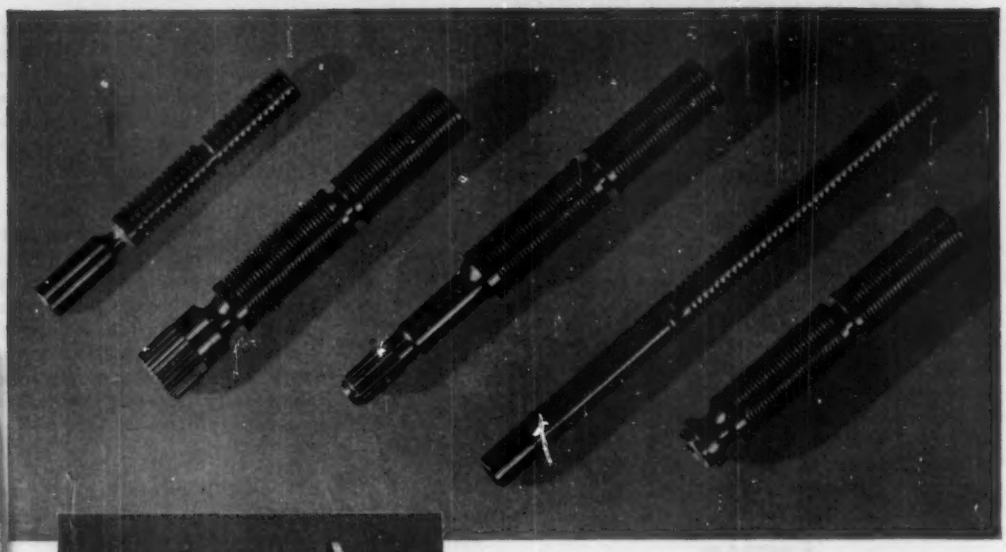
PARTIALLY-ACTIVATED GERMANIUM is the heart of a small radiation counter that is more sensitive than Geiger units of larger dimensions. Device not only counts alpha and beta particles and gamma rays, but it also senses the directions in which they travel.

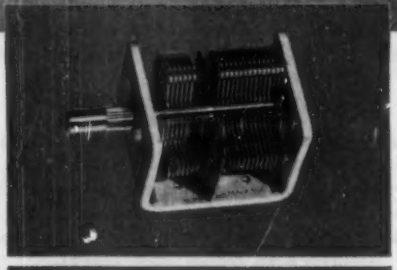


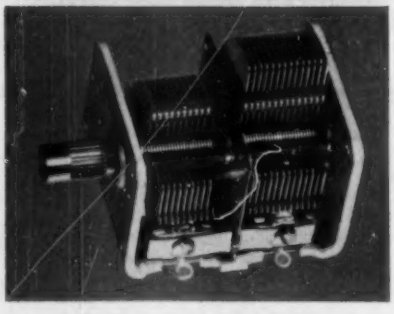
THIS MONTH'S COVER

Test engineers observing air flow through a half-section valve model. Model is made of pliable clay and covered by a transparent acrylic plastic plate. Small streamers, pinned to the model's interior surface, reveal any points causing excessive turbulence. The engineers will then change the contours of the pliable clay to smooth out the air flow. Object of the procedure is to design—by cut and try—the internal valve contours that will gvie a minimum pressure drop. The same test fluid (air) can be used in designing valves for steam, water or hydraulic applications. Artist's drawing is based on Kodachrome, courtesy of Edward Valves, Inc.

For Tough Machining Jobs, Get REVERE FREE-CUTTING BRASS







Above, Model CS, smallest condenser, air space .009". Below, Model B, largest, air space .013". Rotor shafts, shown in top illustration, are Revere Free-Cutting Brass, plates aluminum. Made by The American Steel Package Co., Defiance, Ohio, an important supplier to the electronics industry.

HERE are several examples of the fact that Revere Free-Cutting Brass is really good. These rotor shafts for variable condensers are cut on automatic machines at 3600 r.p.m. Circular tools are used to cut the concentric slots which are .050" deep. Only one cut has to be taken. Approximately 425 pieces are produced per hour on a 6-second cycle. The American Steel Package Company, Defiance, Ohio, produces a number of different condenser models, with air spacing ranging from .009" up to .042". The slots in the shaft of Revere Free-Cutting Brass are all of the same width, regardless of air spacing, namely .014" plus or minus .0002". It takes good machines, good tools, good men, and good metal to work that closely. A report from a Revere Technical Advisor who had collaborated with the company states: "Customer is outstanding in his praise of Revere Rod." . . . If you have a problem in the machining of brass, why not give Revere an opportunity to work with you? The Revere Technical Advisory Service is at your command.

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9. Floor Polisher
10. Refrigerator Water Bottle Cap Slide
11. Ice Crusher
12. Casement Window Hardware
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14. Plumbing Hardware
15. Garbage Disposer
16. Orange Juicer
17. Lighting Fixture
18. Cup Dispenser
19. Electric Waffle Iron
20. Dish Washer
21. Cream Whipper
22. Drink Mixer
23. Electric Knife Sharpener
24. Bread Tray
25. Kwik Cup Coffee Maker
26. Cake Plate
27. Electric Sandwich Grille
28. Food Mixer
29. Food Chopper
30. Large Serving Spoon
31. Toaster
32. Steam Iron
33. Sugar & Creamer Set
34. Small Radio
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44. Ventilating Fan

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SHELBY SEAMLESS STEEL TUBING

UNITED STATES STEEL

Effective sealing of metal-to-metal joints

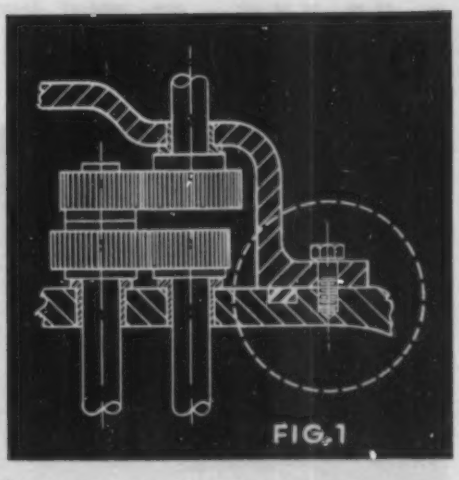
FIG. 1

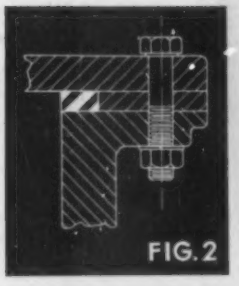
FIG. 2

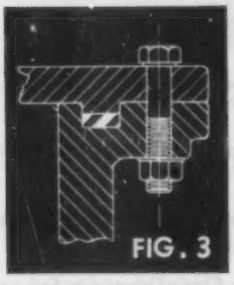
FIG. 3

Effective sealing of metal-to-metal joints requires: (1) complete filling of the recessed gasket channel to provide maximum contact area between gasket and mating flange and (2) correct gasket compression to prevent seepage of the sealed medium or crushing of the gasket.

Both of these requirements can be met with gaskets cut from truly compressible materials like Armstrong's Cork-and-Rubber Compositions.

To fill the channel completely, cork-and-rubber gaskets are cut to full channel width and, depending on compressibility, from 1.25 to 1.5 times channel depth. Because these gaskets actually decrease in volume under load, they do not require relief for sideflow or excessively close gasket and metal tolerances.

Correct gasket compression is also assured with the right cork-and-rubber composition. Each cork-and-rubber material combines controlled amounts of truly compressible cork and non-compressible synthetic rubber. Hence it provides a predetermined degree of compressibility to handle the desired range of flange pressures.

Typical of the metal-to-metal sealing jobs done by cork-and-rubber is the instrument flange in figure 1. Completely confined, the cork-and-rubber prevents seepage of the lubricating oil and permits perfect alignment of the gears.

In figure 2, flat flanges were adapted to metal-to-metal sealing by inserting an annular shim. Here, cork-and-rubber compresses to form a tight seal without tending to flow out of position.

The high-pressure flange shown in figure 3 utilizes a stop to prevent blowouts. By completely filling the confined volume, cork-and-rubber insures a tight seal.

Effective sealing of metal-to-metal joints is but one type of job handled by Armstrong's Cork-and-Rubber Compositions. Your Armstrong representative will gladly help you apply these versatile materials to your application.

Send for this Gasket Handbook

You'll find useful application and specification data in the revised 24-page booklet, "Armstrong's Gasket and Sealing Materials." It contains up-to-date information on straight synthetic rubber, cork-and-synthetic-rubber, and cork composition gasket and sealing materials.

This booklet includes ten technical discussions of the factors influencing modern gasket and joint design. It also suggests methods of putting Armstrong's stock materials to specialized uses in such fields as radio, electrical, automotive, petroleum, and transportation industries.

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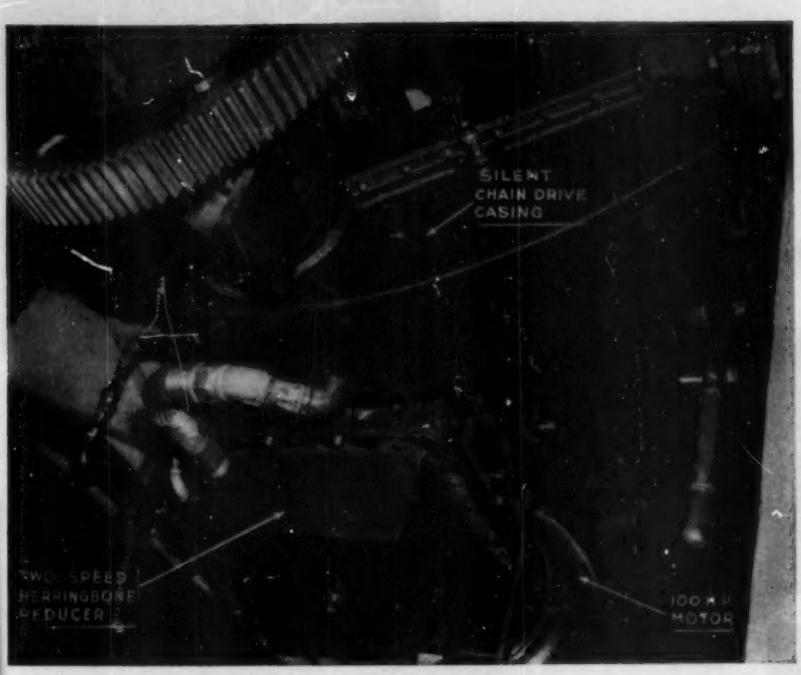
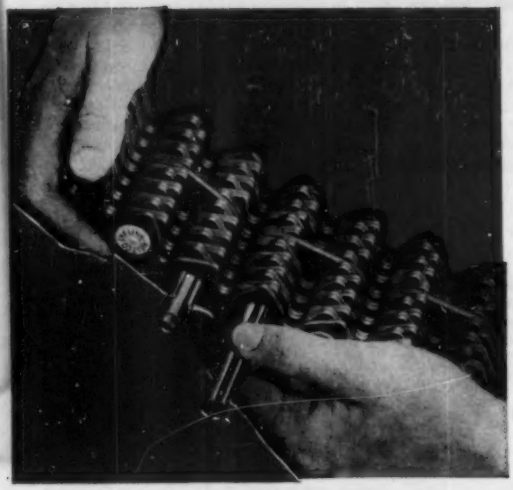


Link-Belt High-Speed Silent Chain Drive from a 100 HP motor to line shaft of world's fastest newspaper printing press . . . Silent Chain operating in oil-tight casing, runs at 3850 or 4700 feet per minute, the speed being preset through a two-speed gear box.



Link-Belt Silent and Roller Chain Drives are Compact—Save Space

Link-Belt Silent and Roller Chain Drives are Positive—No Slip

Link-Belt Silent and Roller Chain Drives are Shock Absorbing—Not Shock Transmitting

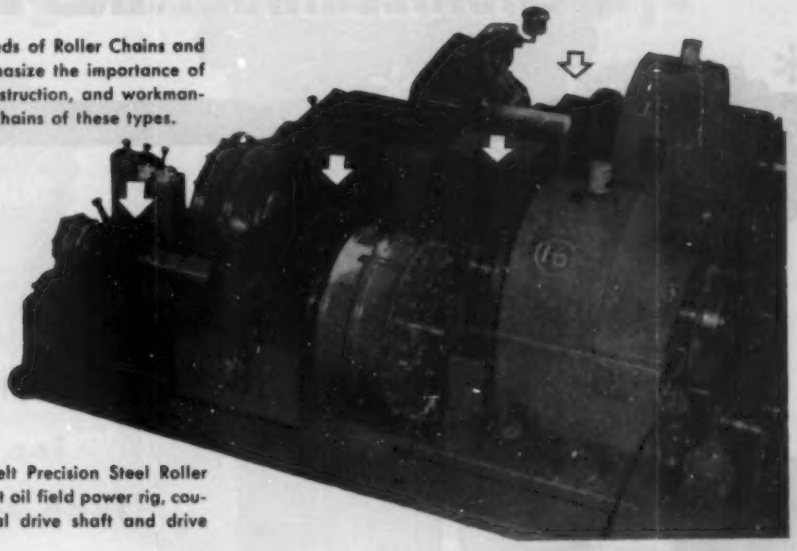
Link-Belt Silent and Roller Chain Drives are Strong —Save Weight

Link-Belt Silverstreak Silent Chain with segmental bushing and round pins insures efficient, long, trouble-free life.

LINK-BELT *Silverstreak*
SILENT CHAIN DRIVES

Positive CHAIN DRIVES

Higher operating speeds of Roller Chains and Silent Chain Drives emphasize the importance of quality of materials, construction, and workmanship found in Link-Belt Chains of these types.



Multiple-width Link-Belt Precision Steel Roller Chains on world's largest oil field power rig, couple two engines to final drive shaft and drive slush pumps.

Link-Belt Precision Steel Roller Chains in sizes from ⅜" to 2½" pitch, single and multiple widths, and Silverstreak Silent Chain in sizes ⅜" to 2" pitch are available from stock. Hundreds of stock sprocket sizes make stock drives available for most chain drive applications.

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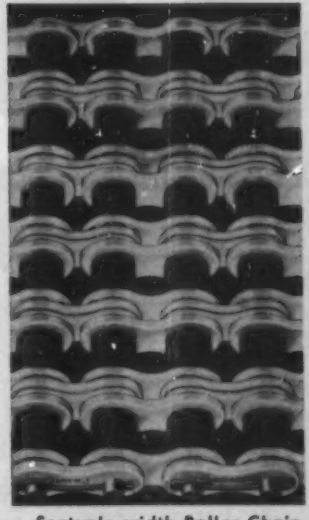
Indianapolis 6, Chicago 9, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices in Principal Cities.



Sextuple width Roller Chain with Shepherd's Crook Cotters designed to resist impact, shock and vibration.

LINK-BELT *Precision Steel*
ROLLER CHAINS AND SPROCKETS

MICRO SWITCH ENGINEERING . . . has met over

FIELD SERVICE

How MICRO SWITCH ENGINEERING provided just the right precision switch for this tape recorder

Illustration shows location in tape recorder of two MICRO precision switches which perform the functions of "forward" and "rewind" limit switches. These switches are sensitive to respond to delicate operating conditions . . . sturdy enough to operate at all times without failure.

Tape recorders are precision instruments, built for long, hard service . . . often in the hands of inexperienced operators.

Few precision switch requirements, therefore, are more exacting than those brought to MICRO SWITCH ENGINEERING by the design engineers of a Midwestern manufacturer of the recorders.

The need was for two small, precise snap-action switches to serve as "forward" and "rewind" limit switches. These switches had to be sensitive enough to respond to delicate operating conditions . . . yet sturdy enough to operate at all times without failure.

Out of a wealth of experience with every known type of precision switching problem, MICRO SWITCH engineers provided two switches which have operated so successfully that the manufacturer tells us that there hasn't been a single instance of performance failure.

This is but one of more than 4600 different switching requirements that MICRO SWITCH ENGINEERING has met and solved. It is one more example of why thousands of design engineers have come to rely on MICRO SWITCH products as basic components.

Your switching problem may be one we have already solved for somebody else. It may be entirely new and different. In either case, you can save time by inviting the cooperation of MICRO SWITCH engineers whose recommendations have met the needs of more than 4600 applications successfully. Call or write MICRO SWITCH, Freeport, Illinois, or any of our branch offices.

4600 design needs successfully!

PRODUCT DEVELOPMENT

ADAPTABILITY STANDARDS

There is always NEWS for Design Engineers in MICRO SWITCH ENGINEERING development

Here is the
NEW MICRO SWITCH
Subminiature . . . a tiny switch for big jobs

This extremely small MICRO precision switch opens a new field of uses for snap-action precision switches, where small space or light weight are important factors.

With less than 1/15th the volume and weight of the standard MICRO snap-action precision switch, the new Subminiature measures 49/64" long, by 3/8" high, by 1/4" wide.

Enclosed in a plastic case, it is provided with pin plunger actuator. The circuit arrangement is single-pole, double-throw. Terminals are of solder lug type.

Electrical capacity tests indicate a rating of 5 amperes, 115 to 230 volts a-c; and 2 amperes, 28 volts d-c.

MICRO SWITCH ENGINEERING provides wide variety of rugged housings for protection, mounting means, conduit connections and versatile application

1. Micro-Limit heavy duty housing with roller arm adjustable in 870 positive lock positions through 360 degrees. Sealed against entrance of dirt, dust or moisture.

2. Die cast housing with sealed roller arm actuator for fast cam operation. Available in four other actuator designs and for side or bottom mounting.

3. Sealed plunger actuator housing for enclosing one or two small V3-1 switches.

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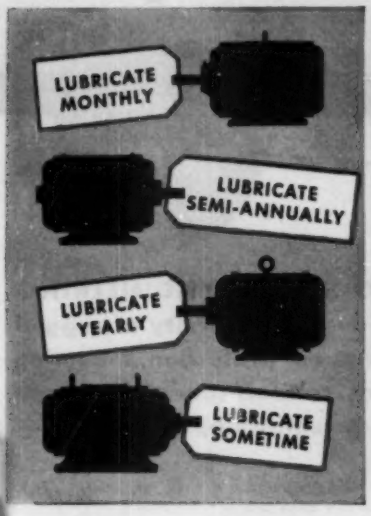

Why take a chance with "Once-in-a-while" lubrication?

Why fuss with motors that require lubrication "every so often?" Whether it's monthly, yearly, every two or three years, or just an indefinite "sometime," it is as much trouble remembering when to lubricate, as it is to do the lubricating. And it certainly isn't a very good way of making sure bearings get proper greasing attention.

There *is* one way to be *sure*. That's with Life-Line motors. Lubrication is *positive*. Bearings are pre-lubricated and factory-sealed. *No* further lubrication is required!

This is the modern way of lubricating motors. Development of special lubricants, up-to-date manufacturing methods and special seals have made it possible.

Records of nearly half a million motors, operating in every type of industry, indicate that pre-lubricated bearings offer: an average saving of $2.70 yearly per motor . . . 41% fewer motor outages due to faulty lubrication . . . complete freedom from lubrication attention.

Today, periodic lubrication is a costly nuisance. So why take a chance with it when Life-Line offers positive lubrication at no extra cost. See for yourself. Ask your Westinghouse representative for a copy of "Facts on Pre-Lubricated Bearings," B-4378, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

J-21559

—— *If you figure LIFE-COSTS . . . you'll figure LIFE-LINE* ——

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Regardless of its design or material used in its sealing elements, what *you* want in an oil seal is complete dependability. Under all circumstances, it must retain lubricants within the mechanism, effectively exclude moisture and foreign matter and give long, trouble-free service. That's dependability . . . and that's what helps sell *your* product.

That is why Chicago Rawhide is so important to you. When you choose Chicago Rawhide oil seals you get unmatched research and manufacturing experience in these three specialized fields:

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Only Chicago Rawhide oil seals give you this three-way assurance of dependability. You can always be sure that Chicago Rawhide "Perfect" Oil Seals will be right for *your* job.

Chicago Rawhide engineering service is always available for the solution of your particular sealing problems.

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Chicago Rawhide Manufacturing Company specializes in mechanical sealing and protective products: oil seals and special diaphragms, boots, gaskets, washers and packings of Sirvene synthetic rubber and Sirvis mechanical leather.

ENGINEERS: We will be pleased to send you engineering data on "Perfect" Oil Seals on receipt of your written request.

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Sirvis Packings

This is a custom-built fulcrum seal. Designed specifically for tractor use, it seals the opening through which the gear shift lever passes into the transmission. This Sirvis leather prevents all foreign matter from entering the transmission, and even under toughest operating conditions, it makes certain dependable performance.

Sirvis packings, like all Sirvis mechanical leathers, are made to deliver long, rugged service. Engineered from the unblemished center portion of select steerhides, they are used to seal oil, water, air or other fluids and gases under various pressures and temperatures.

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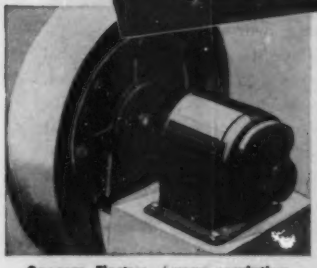
Which of these G-E SILICONE PRODUCTS can help your business?



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There's a place in almost every business for some General Electric silicone product. And almost every day some new way is found to apply the chemical inertness, temperature-resistance and flexibility of silicones.

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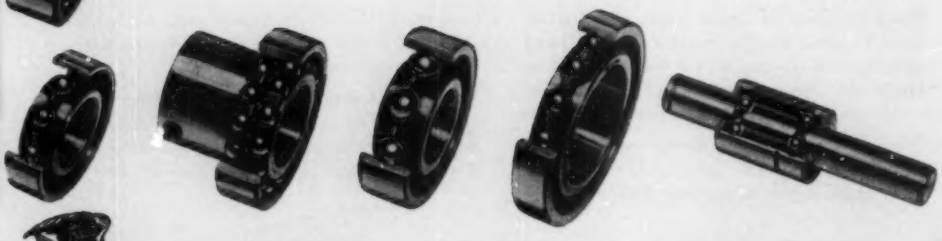

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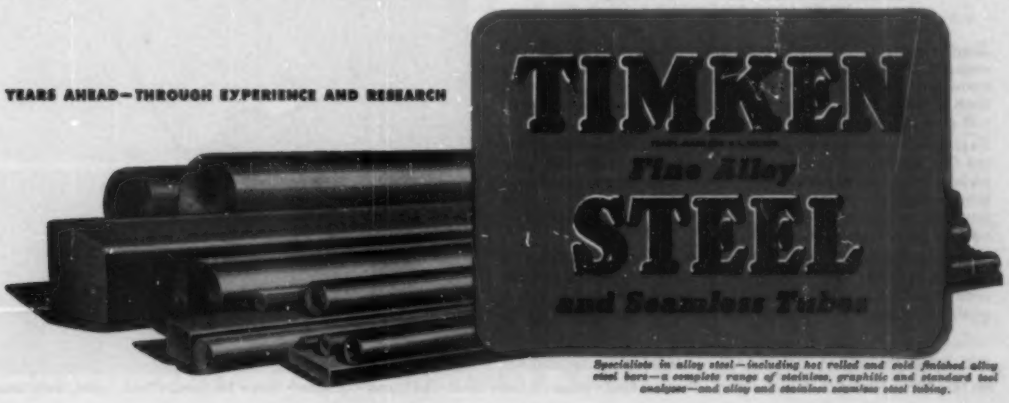
YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH



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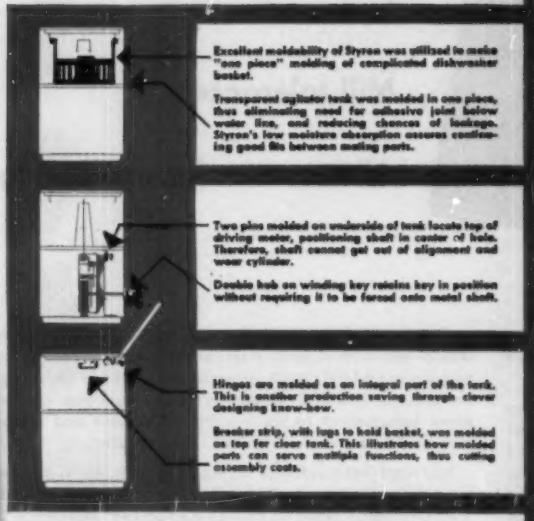
HERE'S HOW A MOLDER'S KNOW-HOW plus STYRON solved another production problem!



Excellent moldability of Styron was utilized to make "one piece" molding of complicated dishwasher basket.

Transparent agitator tank was molded in one piece, thus eliminating need for adhesive joint below water line, and reducing chances of leakage. Styron's low moisture absorption assures continuing good fit between mating parts.

Two pins molded on underside of tank locate top of driving motor, positioning shaft in center of hole. Therefore, shaft cannot get out of alignment and wear cylinder.

Double hub on winding key retains key in position without requiring it to be forced onto metal shaft.

Hinges are molded as an integral part of the tank. This is another production saving through clever designing know-how.

Bracket strip, with lugs to hold basket, was molded on top for clear tank. This illustrates how molded parts can serve multiple functions, thus cutting assembly costs.

Molded and distributed by Ideal Novelty & Toy Company
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Styron was specified by the molder for this Mechanical Toy Dishwasher. This choice meant mass production at low unit cost because Styron has lower material and finishing costs, allows faster assembly and provides finished product quality comparable to very high priced toys.

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WILLIAMS TOOL COMPANY, Brantford, Ontario, Canada selects Texrope Automatic Sheave for Pipe Threading Machines!

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S-t-r-e-t-c-h the work range of the machines you design or build. Give them *extra work capacity* by incorporating REEVES Speed Control as standard equipment.

With REEVES applied to your new models, you replace outmoded, inflexible fixed speed operation with accurate, infinitely variable speed control. Unit cost is reduced; uniformity of product is assured; operating range is expanded to permit the handling of more different shapes, sizes and materials . . . because REEVES delivers exactly the right speed for every operation and every operator under every changing condition.

REEVES is the easiest and most economical of all variable speed mechanisms to build into your machines. The REEVES line is *complete.* Almost always, you'll find a standard design, size, capacity and speed ratio that blends perfectly into your blueprints. For use within the machine framework, REEVES also furnishes "Internal Operating Parts." You also have a choice of manual, push-button or automatic controls.

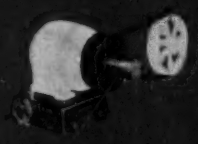
To widen the work range of your machines or improve their performance in any of the eight ways listed opposite, insist on REEVES Speed Control, standard on more than 2,100 different makes of machines. Let a REEVES field engineer look at your speed control problems. His assistance is given gladly, no obligation.

REEVES Performs These *Eight* Basic Functions for Your Machines!

1. Handles more sizes, shapes and materials.
2. Matches variances in number or skill of operators.
3. Compensates for changes in consistency, density or viscosity of materials in process.
4. Accurately controls heating, baking, drying, cooking or chilling time.
5. Maintains uniform peripheral speed (or tension) on decreasing or increasing diameters.
6. Maintains uniform pressure, weight, liquid level, temperature and other variable elements.
7. Regulates conveyor speeds—even to fractions of an inch per minute.
8. Synchronizes all working parts—of one machine or machines operating in series.

Free! The most comprehensive book on speed control ever published! A copy belongs in every machine designer's files. Write for complete REEVES Catalog K29-3N.

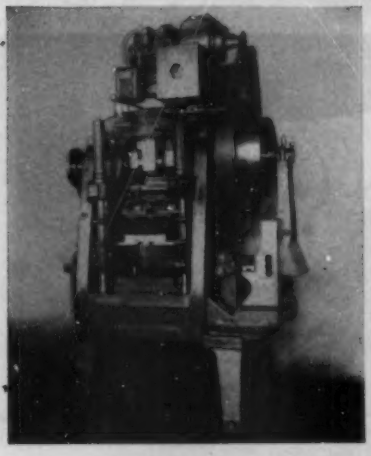
The Three Basic Reeves Speed Control Units



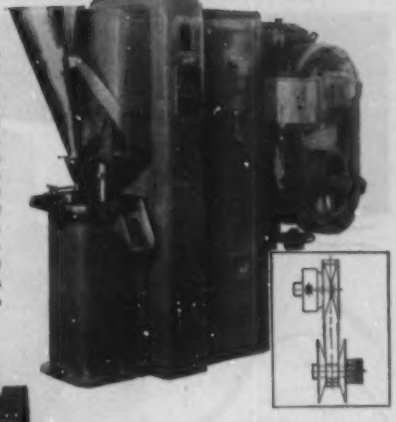
The Latest From Reeves for Your Light Machinery

range into your machines

Speed Control



Left: This Four-Post Power Press, manufactured by the Waterbury Farrel Foundry & Machine Company, Waterbury, Conn., is standardly equipped for variable speed with a REEVES Motodrive. This variable speed unit permits the operator to vary machine speeds between 100 and 300 rpm, depending on the type of work and the thickness or composition of the material being processed. The press is a patented type, design of which emphasizes high speed in combination with accurate tool alignment.



Above: This 55-ton Tablet Press, manufactured by the Arthur Colton Company, Detroit, is powered by a 7½ hp motor and is standardly equipped with a No. 66 REEVES Vari-Speed Motor Pulley. The press is designed for pre-forming and molding plastics, powdered metal and ceramic pieces of round and odd shapes, plain or with cored holes. The REEVES Vari-Speed Drive wid'ens the work range of the press by permitting it to run at maximum speeds on small work and at decreased speeds for work requiring greater die-fill time. (Inset is schematic drawing showing hook-up of REEVES unit.)

Above: A No. 4 REEVES Variable Speed Transmission, with speed ratio of 6:1, is standard equipment on this 12" x 24" low frame, open front, direct action Hydraulic Lift Embossing Machine, manufactured by the Meadows Machine Works, Inc., South Kearney, N. J. This variable speed unit permits the handling of an exceptionally wide range of materials, including coated fabrics, coated and uncoated paper, and unsupported plastic film. By means of pressure and heat, specially engraved steel rolls calender various effects, ornamental designs, etc., to the fabric being run. The REEVES Transmission allows the speed of the rolls to be varied, as required by the material in process.

accurate · variable

REEVES *Speed Control*

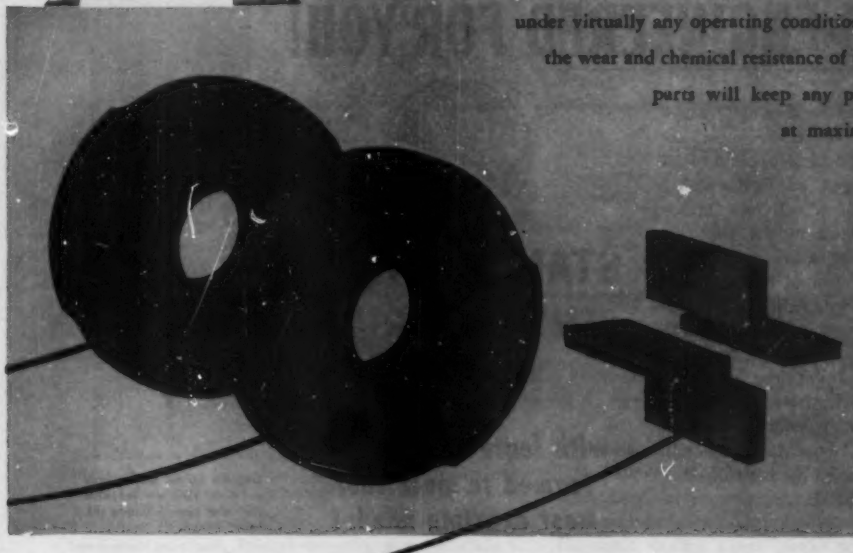
REEVES PULLEY COMPANY • COLUMBUS, INDIANA

Recognized Leader in the Specialized Field of Speed Control Engineering

SMALL COMPACT HIGH-PRESSURE PUMP WITH **GRAPHITAR**
(CARBON-GRAPHITE)
VANES AND END-PLATE BEARINGS
started in continuous operation April, 1949—
still running smoothly today

THE UNITED STATES GRAPHITE COMPANY

After 7209 hours of continuous trouble-free operation (60 hours were dry run at top speed) this powerful little pump, a product of the Procon Pump And Engineering Company of Detroit, Michigan, is still running smoothly at 1800 RPM, 520 psi, handling 55 gallons of dirty unfiltered water per hour. Graphitar vanes and end-plate bearings are in the most vital spot, where the speed, pressure and stress is the greatest. Makers of the Procon Pump know that *Graphitar* parts can be counted on to stand up under virtually any operating conditions. They know the wear and chemical resistance of these *Graphitar* parts will keep any pump operating at maximum efficiency.



GRAPHITAR *Is Versatile.* Self-lubricating, lightweight, highly resistant to wear and temperature extremes, *Graphitar* is the ideal material for seals, bearings, pistons, cylinder liners and many other parts. One great *Graphitar* feature is resistance to chemical attack, even by concentrated acids such as hydrofluoric and hydrochloric. We are equipped to produce *Graphitar* parts in any practical size and shape. Smaller parts can be ground to tolerances as close as .0005". Send us sketches or descriptions of your products and let our engineers advise how *Graphitar* parts can improve the efficiency of your products. Write for our new 64 page catalog.

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

Designer's

NOW!

PACKAGED ADJUSTABLE-SPEED CUSTOM-ENGINEERED FOR YOU!

Yes, these and many other features of Thy-mo-trol®—features that make it the most accurate, most versatile, and fastest-acting of all General Electric packaged adjustable-speed drives—are now standardized with new "building block" flexibility. That means you can order this wonder-working, all-electronic system with just the combination of standard and optional features you need. Already service-proved on thousands of machines, Thy-mo-trol now more than ever meets your most demanding requirements. In addition, and at lower cost, its new "building block" design allows you in many instances to use it economically for your less exacting applications. Made in standard ratings from 1/40 to 30 hp, it's fully described in Bulletin GEA-5337.

STANDARDIZED THY-MO-TROL DRIVES

—with features like these teamed to meet your most exacting needs!

Any speed range from 5:1 up to 100:1. Select the range you need, no more, no less.

Stepless speed adjustment to give you an infinite choice of speeds within the rated range.

Easy automatic operation, using geared or cam-driven potentiometers, selsyns, or reactors.

Preset speed with push-button control of any operating, jogging, or creeping speeds.

Torque limit protection to minimize the possibility of damage should the machine jam or be overloaded.

Complete speed control from start to stop—including acceleration, deceleration, and reversing.

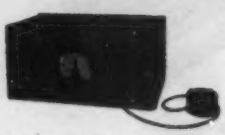
Precise speed regulation to the accuracy required—even 0.5%—despite voltage or motor temperature changes.

GENERAL ELECTRIC

668-81

Digest

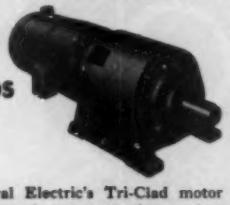
PRODUCT HIGHLIGHTS



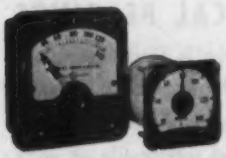
TO TEST METAL PARTS —*QUICKLY!*

Here's a fast, economical way to reduce scrap loss due to mixed material or incorrect processing of ferrous or nonferrous parts. Compare their composition, heat treatment, hardness, or plating thickness against a standard by means of the General Electric metals comparator. Equipment comprises an electronic unit mounted in a steel cabinet, plus either a test coil (shown) or a test head, depending on the shapes of parts to be tested. Operates from a single-phase, 60-cycle, 110-volt supply. See Bulletin GEC-566.

TO ADJUST LOW-RANGE SPEEDS —*STEPLESSLY!*



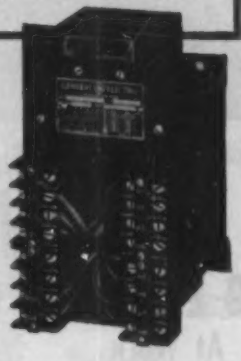
Newest line added to General Electric's Tri-Clad motor family is the a-c adjustable-speed gear-motor for stepless speed adjustment in the low ranges. In standard ratings from 3-15 hp, 35/12 to 602/201 rpm, this compact unit combines a standard type ACA motor with an AGMA Class II open horizontal gear unit. Result: mounting is easier, space is saved, installation and maintenance costs are cut. What's more, efficiency is high because of low motor and gear losses. See Bulletin GEA-4883.



TO CHECK TEMPERATURES —*ACCURATELY!*

Most temperatures commonly met in industry can be accurately, remotely measured with General Electric temperature indicators. In two types, they provide a wide temperature span and high speed of response. Resistance thermometers cover the range up to 300 F, have a minimum span of 150 F each and an accuracy up to ±1 per cent. Thermocouple thermometers, with round or square cases, measure from −50 to 3000 F with a minimum span of 250 F each, are accurate to ±2.5 per cent, and, with accessories, can be used portably or panel mounted. See Bulletin GEC-565.

Versatile Transformer FOR A Variety of Voltages



Here's a point to remember: Standards recently recommended by the Joint Industry Conference are more than met in General Electric's complete line of machine-tool control transformers.

The all-purpose (multi-tap primary) group is made in ratings from 0.150 to 3.0 kva for both 50- and 60-cycle circuits. Equipped with eight primary taps—208, 220, 380, 400, 416, 440, 500, and 550 volts—110/92-volt secondary, these versatile units fit practically every input-voltage condition, reduce inventory and storage costs. Compact design saves panel space, simplifies wiring. Built-in protection against damage from short circuits and sustained overload is also included. For more information, write for Bulletin GEA-4887.

General Electric Company, Section F668-81
Apparatus Department, Schenectady 5, N. Y.

Please send me the following bulletins:

V for references purposes
X in connection with immediate projects

- ☐ GEA-4883—Adjustable-speed gear-motors
- ☐ GEA-4887—Machine-tool transformers
- ☐ GEA-5337—Thy-mo-trol drives
- ☐ GEC-565—Temperature indicators
- ☐ GEC-566—Metals comparator

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS! You'll find "everything electric" for machinery manufacturers in the General Electric section.

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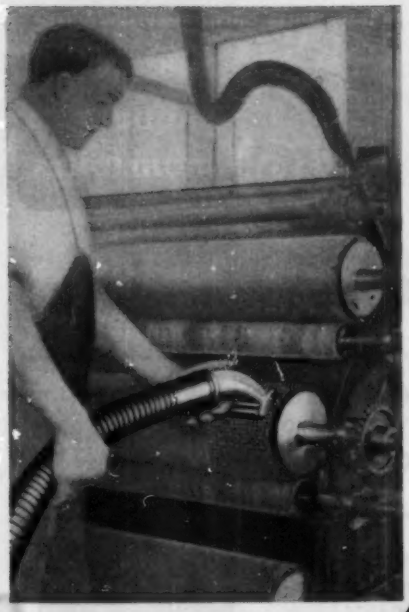
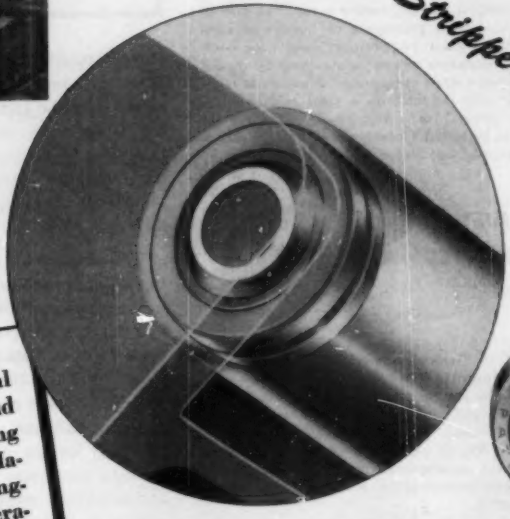


If You Could Look Inside

This Worker and Stripper Tool—



You Would Find These HEIM BEARINGS At Work

By inserting HEIM Unibal Spherical Bearings in each end of each seamless steel tubing roll, the Abington Textile Machinery Works, North Abington, Mass. achieved the imperative freedom of rotation which the self-aligning HEIM bearing gives in an economical assembly. This tool is connected by means of a flexible hose to a high-powered vacuum system for cleaning delicate needle points on a card.

HEIM UNIBAL SPHERICAL BEARINGS

Whether your bearing application is large or small, our engineering department will be glad to demonstrate how HEIM Spherical Bearings with the single ball can improve the performance and service life of your machines.

Catalog on request.
Distributors in principle cities.

THE HEIM COMPANY
FAIRFIELD CONNECTICUT

"A BOLT IS ONLY HALF A FASTENER WITHOUT A NUT!"

FOR A *Complete* QUALITY "FASTENER TEAM" USE LAMSON NUTS!

COLD PUNCHED · HOT PRESSED · COLD FORGED · MILLED

It takes *two* to complete a "fastener team"... a bolt and a nut. Quality bolts *deserve* the plus values found in Lamson nuts ... the accurate fit and dependable holding power.

Lamson makes many different types of nuts in hundreds of shapes, styles and sizes ... a nut for almost every purpose.

Whether you need standards or specials, in plain, plated or stainless steel—in brass, bronze or aluminum, Lamson makes them all.

Think of Lamson nuts when you buy bolts ... and buy *both!*

The LAMSON & SESSIONS *Co.*

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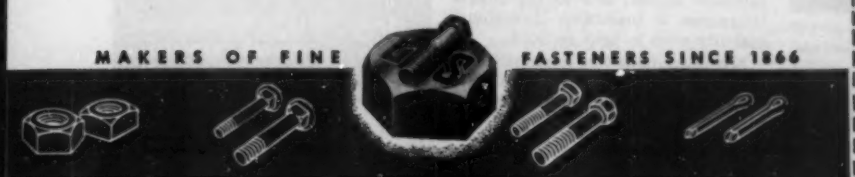
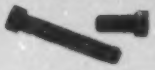
MAKERS OF FINE FASTENERS SINCE 1866



BOLTS • NUTS • SCREWS • COTTERS • STUDS • RIVETS • SPECIALS • SCREW MACHINE PRODUCTS

CUT ALONG THIS LINE

LAMSON LOCK NUTS: Economical, vibration-proof. Can be re-used repeatedly.



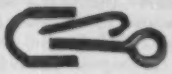
"M35" SET SCREWS: Cup point type, hardened, heat-treated.

COTTER PINS: Steel, Brass, Aluminum and Stainless Steel.

SPECIAL NUTS: Cone, Barrel, Oblong, Plier, Tri-Slot, Half-round, etc.

PHILLIPS AND CLUTCH HEAD: Machine Screws and Tapping Screws.

MILLED STUDS: Concentric, accurate, in a full range of sizes.



"BENT" BOLTS: Including U Bolts, Eye Bolts, Hook Bolts, etc.

WEATHER-TIGHT BOLTS: Eliminate counter-boring in wood assemblies.

PIPE PLUGS: Forged Steel, heat-treated.

FOR MORE INFORMATION ON LAMSON *Money-Saver* FASTENERS ..... CHECK COUPON and CLIP THIS STRIP

The Lamson & Sessions Company
1971 W. 85th St., Cleveland 2, Ohio

NYLON PLASTIC KEEPS BELL HELICOPTER TRANSMISSION WORKING OVER 40 TIMES LONGER

Combination of economy and operating properties, found only in molded Du Pont nylon, solves problem of making efficient bearing cages

INCREASE in service life of transmission from *25 hours to well over 1000 hours*—that's the success story of molded nylon bearing cages used in the Bell helicopter transmission.

Three years ago Bell Aircraft began assembly-line production of its Model 47B helicopter. They met with trouble in the bearing cages of the transmission. It was found impossible to get over 25 hours of reliable service life from any standard anti-friction bearing small enough for the job.

THE NYLON BEARING CAGE is a key part of this improved pinion assembly, which has increased the service life of the Bell helicopter transmission from 25 to over 1000 flight hours. (Bearing cage molded by Peerless Molded Plastics, Inc., Toledo)

A long search was begun for a satisfactory part to conform with Bell's exacting specifications. Some materials cost too much, others could not meet all service requirements, particularly for the lower stages, which bear the brunt of the load. Then they tried molded nylon cages, and nylon was the answer. Since the advent of nylon cages, no bearing failures have been reported even in helicopters with over 1000 flight hours.

Nylon's properties solved the problems encountered in this application. Its light weight keeps centrifugal loads to a minimum. Its excellent bearing properties call for the barest lubrication. Hard and tough, nylon absorbs shocks and vibrations. And it's readily and economically molded in simple or intricate shapes, and to the closest tolerances. It maintains dimensional stability even in light sections.

Nylon's outstanding combination of properties may help you solve design and production problems at actual cost savings. For more information on nylon and other Du Pont plastics, write today for free literature. E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Plastics Sales Offices: 350 Fifth Avenue, New York 1, N. Y.; 7 S. Dearborn Street, Chicago 3, Ill.; 845 E. 60th Street, Los Angeles 1, Calif.

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PLASTICS
Better Things for Better Living
. . . through Chemistry

the Name is... **FAIRBANKS-MORSE**

Here's "CUSTOMER APPEAL" for You!

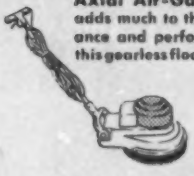
Here's the Axial Air-Gap Motor

Motor users have been quick to add the advantages of the Axial Air-Gap Motor — the motor that is lighter than conventional types by 30% — shorter by over 40%. These advantages add up to a convincing amount of "customer appeal" to anyone interested in a more compact, streamlined and attractive driven machine. Too, Axial Air-Gap Motors offer additional appeals: they have a minimum number of parts, are easy to service and lend themselves to simple mounting — horizontally, vertically or right angle pivot base. Available as polyphase squirrel cage and capacitor start single phase motors — up to ten horsepower — they deserve first consideration for a wide range of applications.

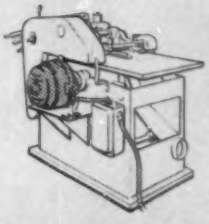
Send for Axial Air-Gap Motor bulletin!

Bulletin 2760 gives the whole story on Axial Air-Gap Motor design, application and construction. Write or call your nearest Fairbanks-Morse branch office (listed on these pages) for your copy.

Where Space, Weight and Appearance Count



A ¾ horsepower Axial Air-Gap Motor adds much to the appearance and performance of this gearless floor polisher.



Reduced overhang, thanks to the Axial Air-Gap Motor, is a decided asset on this modern saw.

This drum hoist is lighter, more compact through the use of the Axial Air-Gap Motor.

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the Name is . . .

Here's "CUSTOMER APPEAL" for You!

General purpose protected frame motors

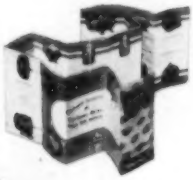
Totally enclosed fan-cooled motors

Totally enclosed non-ventilated motors

Here are the motors with indestructible *copper-spun* rotors!

Here is an exclusive feature of Fairbanks-Morse polyphase squirrel-cage motors—a one-piece, centrifugally cast copper winding that, to a greater extent than other types, is dense, ductile, strong—with higher conductivity and lower thermal expansion. This is heavy duty design that can stand severe service and high temperatures. It enables Fairbanks-Morse Motors to operate efficiently under adverse conditions—types of service where ordinary motors deteriorate rapidly. It's a design that anyone ought to know more about before buying any motor, for it assures more successful low-cost operation.

"Pocket Panorama" shows the whole "line-up"



Here in a handy pocket pamphlet are illustrated over 40 types and sizes of Fairbanks-Morse motors and generators. Write or call your Fairbanks-Morse branch office to get your copy.

Explosion-proof motors

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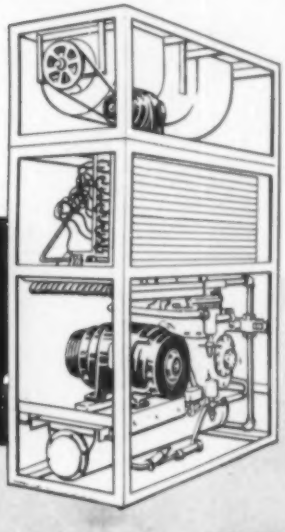
FAIRBANKS-MORSE

Here's Built-in Longtime Motor Satisfaction

Cross-flow ventilation is another exclusive Fairbanks-Morse advantage.* It means uniform, symmetrical cooling that eliminates hot spots and prolongs the life of the insulation. Openings are arranged so that there are no exposed moving parts to catch clothing or fingers—a safety factor of prime importance in many installations.

There are many other important features that have made Fairbanks-Morse a name respected wherever motors are used. Ask your Fairbanks-Morse motor specialist about them and you'll find out why, for the broadest range of your motor services, it's best to consider Fairbanks-Morse first.

*NEMA frames 224 to 365 inclusive



For EXAMPLE —

This popular self-contained, water-cooled air conditioning unit has a ten-horsepower motor driving the compressor and a one-horsepower motor on the fan. "We have been using Fairbanks-Morse motors for ten years," says the company president, "and we have found them highly satisfactory—silent in operation—and they demand little servicing."

This company uses Fairbanks-Morse Motors from ¾ horsepower all the way up to 50 Horsepower and is one of hundreds of companies standardizing on Fairbanks-Morse, for long-time motor satisfaction.

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Nothing Else Like It!

THE MOTORGEAR

Industry's most compact slow speed unit

Here's a sure, easy way to simplify your slow speed drives. The unique Motorgear combines the modern, dependable Axial Air-Gap Motor with a simple, sturdy helical gear train. The compactness and ease of mounting of the Motorgear make it more easily adaptable to a wider variety of applications. Wherever it is used, the Motorgear improves the appearance as well as the performance of the driven machine. For details write or call your Fairbanks-Morse branch office for your copy of the Motorgear bulletin.

FAIRBANKS-MORSE,

a name worth remembering

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ST. PAUL 1, MINN.
220-26 E. Fifth Street
Garfield 4335

SALT LAKE CITY 1, UTAH.
153 W. Second South St.
32106

SAN FRANCISCO 7, CALIF.
630 Third Street
Exbrook 25855

SEATTLE 99, WASH.
Salmon Bay Terminal
Alden 6600

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403 South Main St.

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WASHINGTON 5, D. C.
1000 Vermont Ave., N. W.
District 669

FAIRBANKS-MORSE de MEXICO S. A.,
Balderas 146, Mexico 1. D. F. Mexico

Export Division: NEW YORK 4, N. Y., 80 Broad Street

AEB 100.10
Prtd. in U.S.A.

answer to "difficult" design problems:

Molded rubber parts engineered for mass production

WHEN faced with the problem of designing parts where rubber's unique characteristics provide the only answer, engineers are turning more and more to Goodyear—for the following reasons:

Universal experience—as the world's largest rubber company Goodyear has far greater technical knowledge in molding rubber and the new rubber-like plastics to meet your exact requirements in specific gravity, elongation, tear, hardness, shear, tensile, and resistance to temperature extremes, abrasion and chemicals.

Superior facilities—the Goodyear molded rubber plant at St. Marys, Ohio, is the largest and most modern in the industry. It has complete equipment to produce in quantities required to keep your production line going at capacity—at low cost per unit.

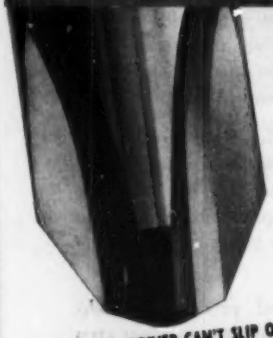
Quality control—advanced production techniques, rigid inspection and control at every step insure exact uniformity of parts in quality and performance to meet your design specifications.

If you have a design problem in rubber, consult the G.T.M.—Goodyear Technical Man—or write direct to:

Goodyear, Molded Goods Dept.,
St. Marys, Ohio.

GOODYEAR

THE GREATEST NAME IN RUBBER



4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS

AMERICAN SCREW CO.

completes move to New Plant

. . . enters New Era in Quality and Service

After one hundred and twelve years at its Providence locations, the American Screw Company has moved its "know-how" and facilities to its one-floor modern streamlined plant at Willimantic, Connecticut. This building now houses all administrative, engineering, production, purchasing, sales, and research personnel.

Our new plant is completing its "shakedown cruise" . . . and is now turning out high-quality American Phillips and Slotted Fasteners in ever-increasing quantities.

Here, the newest and finest of high-production equipment, operated by employees under ideal working conditions, will set a new standard of American service to all fields of industry.

AMERICAN SCREW COMPANY, WILLIMANTIC, CONNECTICUT

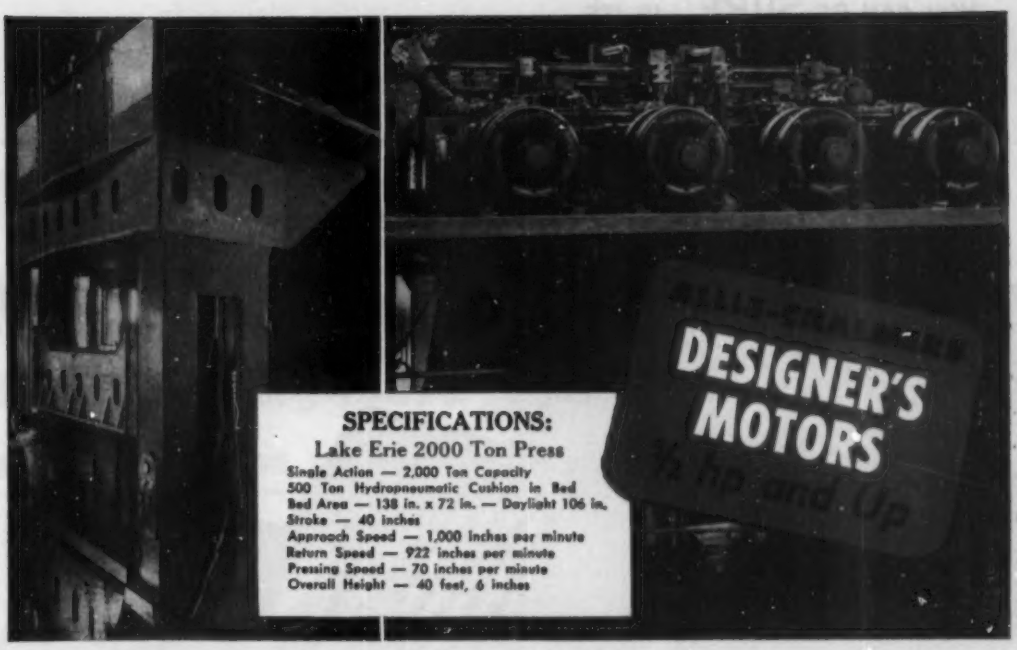
Plant at Norristown, Pa.

Warehouses at: Chicago 11: 589 E. Illinois St. Detroit 2: 502 Stephenson Bldg.

AMERICAN PHILLIPS *Screws*

ALL TYPES

ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)



SPECIFICATIONS:
Lake Erie 2000 Ton Press

Single Action — 2,000 Ton Capacity
500 Ton Hydropneumatic Cushion in Bed
Bed Area — 138 in. x 72 in. — Daylight 106 in.
Stroke — 40 inches
Approach Speed — 1,000 inches per minute
Return Speed — 922 inches per minute
Pressing Speed — 70 inches per minute
Overall Height — 40 feet, 6 inches

2000 Ton Lake Erie Press uses 4 Allis-Chalmers 125 hp Motors!

NEED LARGE MOTORS for a giant 2000 ton press? ½ hp motors for a new bench lathe design? 10,000 hp motors?

You can probably select a *standard* Allis-Chalmers motor to fit your job.

GET THIS 4-POINT MOTOR PROTECTION WITH ALLIS-CHALMERS *Safety Circle* MOTORS

1 *Rigid Cast Iron Frame* completely surrounds all working parts . . . resists corrosion . . . gives added mechanical strength.

2 *Pre-lubricated Bearings* operate longer periods without attention. If motor is dismantled, it is recommended that bearings then be cleaned and repacked.

3 *Multiple Dipped and Baked* stator windings give *extra* protection against heat and moisture.

4 *Pressure-Cast Rotor* has no rivets or welds . . . there's nothing to rattle or shake loose.

BACK YOUR MOTOR UP WITH ALLIS-CHALMERS CERTIFIED SERVICE

An added reason for supplying Allis-Chalmers motors on your equipment is *Certified Service*. Your customers get this Allis-Chalmers service in every major industrial area. It is backed by factory methods and genuine A-C service parts.

And when you do specify Allis-Chalmers motors, be sure to order matching control as well.

SEND LITERATURE CHECKED BELOW:

ALLIS-CHALMERS, 1002A SO. 70 ST.
MILWAUKEE, WIS.

Please send me:
Handy Guide for Electric Motors
Bulletin 51B6052
Flange Motor Specification Sheet
5157234
General Purpose Motor Controls
Bulletin 1487132

Name .....
Title .....
Company .....
Street .....
City ..... State .....
A-2994

ALLIS-CHALMERS A-C

SOLD AND APPLIED BY AUTHORIZED DEALERS, AND DISTRICT OFFICES THROUGHOUT U. S., SERVICED BY CERTIFIED A-C SERVICE SHOPS

YOU CAN BE **SURE**.. IF IT'S

Westinghouse

Tomorrow's

Westinghouse

life-line starter

TOMORROW'S STARTER—**TODAY!**

Uniform Design
in NEMA Sizes
0 through 4
to 100 hp; 600 volts

Starter, TODAY!

New Westinghouse *Life-Line*starter*

FOR BETTER MOTOR PROTECTION . . . LOWER OPERATING COSTS

This all-new line of a-c motor starters is announced *only after* 6 years' actual trial service, backed by 40 years of user experience in building motor controls.

HERE'S WHY it IS tomorrow's starter, TODAY:

- **Eliminates Solenoid Friction and Misalignment**—Inverted clapper-type magnet balanced on knife-edge.
- **Prevents Accidental Opening or Closing of Contacts**—Seesaw balance of clapper prevents accidental opening—kickout spring prevents accidental closing.
- **Provides Uniform Line**—Appearance and construction, NEMA sizes 0 through 4.
- **Provides Positive Opening of Contacts**—Kickout spring provides force to open contacts.
- **Provides Straight-through Wiring**—Three line leads at top; three load leads at bottom.
- **Provides Positive and Precise Overload Protection**—Snap action bi-metal DISC instead of "solder pots" or bi-metal strips.
- **Permits Front-removal of ALL Parts**—No special tools required.
- **Corrosion-resistant Parts All Plated**—Enclosure Bonderized.
- **Meets NEMA Standard Mountings.**
- **Gives Quietest Operation**—Self-aligning magnet construction.

J-30019

*Trade Mark

See for yourself. Ask your Westinghouse representative to show you "the inside story"—a Trans-Vision presentation of the Life-Linestarter. Get the facts. Write for 20-page complete line booklet, B-4677. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

UNBRAKO

KNURLED SOCKET HEAD SHOULDER SCREWS

"HEAD AND SHOULDERS" ABOVE THEM ALL!

UNBRAKO Socket Head Shoulder Screws with *Knurled* Heads . . . are preferred by die-makers everywhere . . . but are useful for many machine applications. Their knurled heads provide a slip-proof grip—even if fingers and heads are oily or greasy—thus materially speeding production.

UNBRAKO Shoulder Screws are available in full range of standard sizes—other sizes to special order.

Write for further details, today.

Knurled Head Socket Cap Screws
Flat Head Socket Cap Screws
Self-Locking Socket Set Screws
Knurled Head Shoulder Screws
Precision-Ground Dowel Pins
Fully-Formed Pressure Plugs

SPS STANDARD PRESSED STEEL CO.

JENKINTOWN 28, PENNSYLVANIA

SECOND OF A SERIES

Know Your Plastics

IT MAY MEAN BETTER AND FASTER PRODUCTION... AT LOWER COST!

When you investigate plastics for your new or re-designed product, think first of BAKELITE Plastics. The BAKELITE family of plastics includes those in greatest demand. This gives you a wide selection, all from one supplier.

The chances are that you will find the one plastic that is best suited to your production facilities, and also the plastic that gives best qualities to your finished products at the lowest possible cost!

This message deals with **"BAKELITE" PHENOLIC LAMINATING PLASTICS**

1. DECORATIVE PANELING

The widely used decorative laminates have core stocks made with BAKELITE Phenolic varnishes which impart such characteristics as high tensile, flexural and compressive strengths, and lightness in weight.

Typical uses: Table, counter, and bar tops; wall paneling.

2. TRANSLUCENT SHEET STOCK

The translucent grades transmit and diffuse light. Because they are heat-resistant they can be used near light sources. They "accept" close register multicolor printing and silk screening.

Typical uses: Radio and television dials; illuminated signs and displays.

3. LARGE INDUSTRIAL PANELS

Large size panels up to 5 ft. 7 in. by 12 ft. 9 in., by ⅛ in. and larger on special order, have high mechanical strength, are lastingly smooth, and resistant to moisture and chemicals.

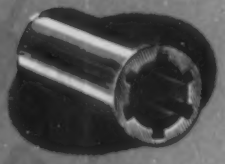
Typical uses: Pasting boards for tanneries; work table surfacing.

4. ELECTRICAL INSULATION

Superior electrical insulation for high frequency circuits, with good mechanical strength, moisture resistance, heat resistance, machinability, permanence of form, and economy.

Typical uses: TV, radio, aviation, and automotive contact insulators.

5. HEAVY DUTY BEARINGS



Heavy duty laminated plastic bearings have unusually long service life as compared with soft metals. They require no lubricants other than water, and will not score shafts.

Typical uses: Slipper and roll neck bearings for steel mills; marine propeller-shaft bearings.

6. INDUSTRIAL GEARS AND PINIONS

Laminated plastic gears are resistant to oil, grease, and moisture. With high tensile and impact strength, they have long, economical service life with remarkable operating quietness.

Typical uses: Automotive timing gears; industrial gears and pinions.

7. MACHINED PARTS

Plastic laminates are readily machined by standard tools, can be threaded, tapped, milled, turned, punched, and sawed. Certain grades are adaptable to low-cost postforming in simple jigs.

Typical uses: Ball bearing retainers; aircraft pulleys; telephone selector units.

8. CHEMICAL HANDLING EQUIPMENT

Plastic laminates are non-corrodible and resistant to water, brine, oil, ordinary solvents, most acids and weak alkalies. They retain high mechanical strength and great resistance to wear under corrosive conditions.

Typical uses: Chemical pump parts; electroplating barrels; textile spinning pots.

9. MOLDED LAMINATES

This class of plastics lies midway between conventional molding and laminating materials. They provide the strength and wear resistance of laminates in shapes and forms molded to precise dimensions.

Typical uses: Industrial truck wheels; miners', firemen's and workmen's helmets.

Laminates made with BAKELITE Phenolic Laminating Varnishes are available in sheet, tube, rod and molded-laminated forms. They are produced by application of heat and pressure on layers of paper, fabric, asbestos, or glass cloth impregnated with BAKELITE Phenolic Laminating Varnishes. The resulting materials are infusible and insoluble—possessing many properties for myriad uses. Specific instructions on machining, bonding, and postforming laminated plastics made with BAKELITE Phenolic Laminating Varnishes can be obtained from individual laminators. The names of leading laminators will gladly be furnished—along with technical assistance from Bakelite's representatives—if you will write to Department M-10.

Bakelite Phenolic LAMINATING PLASTICS

BAKELITE DIVISION

BAKELITE DIVISION, *Union Carbide and Carbon Corporation*, 30 East 42nd Street, New York 17, N. Y.

HERE'S HOW RE-DESIGNING WITH AN INCO NICKEL ALLOY ADDED NEW SELLING POINTS TO THE OLD FAMILIAR DIAPER PIN

You, too, can mother an idea

What's new about a safety pin?

Plenty, if it's a Kwik-Pin . . . a real *safety* pin.

First, consider an ordinary safety pin. Open, it's as dangerous as a fishhook. When you stick it into the diaper, you use two hands, dig down and then up, with a silent prayer that you haven't included the baby. When it's closed, it may pop open unseen (but not always unfelt). When it's lost, you search frantically, for it may be inside the baby.

Now look at the Kwik-Pin and see how this manufacturer re-designed an old product, used Monel wire, and added new selling points to a commonplace item.

The Kwik-Pin is safe open; safe closed. Never can pop open. You can pin straight through 14 layers of diaper and undershirt with an easy, one-hand, squeeze-push action of the fingers. Hygienic, too, because it's made of colorfast plastic and rustless Monel. And you can easily spot it anywhere.

The manufacturer chose Monel because it provided strong, hard, spring-temper wire that would be free of rust and corrosion. Yet, Monel wire was economical enough to let the Kwik-Pin retail at 25¢ per card of 4.

If you're planning a new product, or re-designing an old one, give some thought to the metals that can add extra performance and extra selling points . . . *the Inco Nickel Alloys.*

INCO Nickel Alloys

Monel® • "R"® Monel • "K"® Monel • "KR"® Monel
"S"® Monel • Inconel® • Nickel • "L"® Nickel
Duranickel® • Permanickel®

"Task Metals" for Industry

EMBLEM OF SERVICE
INCO
TRADE MARK

SEND FOR NEW FOLDER, *"If Wire Has You Snarled."* It contains helpful information on the mechanical and corrosion-resisting properties of Monel, Nickel and Inconel wire. Also includes a sample coil of Monel wire, plus the names and addresses of 36 suppliers. If you care to outline your problem to us, we'll be glad to forward samples of recommended wire for testing.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

When close tolerances and light weight are design requirements, investigate die castings of Dow

MAGNESIUM

the world's lightest structural metal!

Magnesium is a full third lighter than the next lightest structural metal and can be die cast to production tolerances of 0.0015" per inch. These qualities plus good strength and shock resistance make magnesium the logical material for many die casting applications.

The excellent casting accuracy of magnesium die casting alloys often eliminates machining operations necessary with other materials. When machining is required, it can be done at lower cost, for magnesium is the easiest die casting material to machine. Slots and small diameter cored holes can be cast with little or, in some cases, no taper since magnesium does not solder to the die.

Investigate magnesium die castings! Dow magnesium die castings are priced competitively. See how they can improve your product or cut its cost. For more information, write Dept. MG-46.

MAGNESIUM DIVISION

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington • Atlanta • Cleveland • Detroit
Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle
Dow Chemical of Canada, Limited, Toronto, Canada

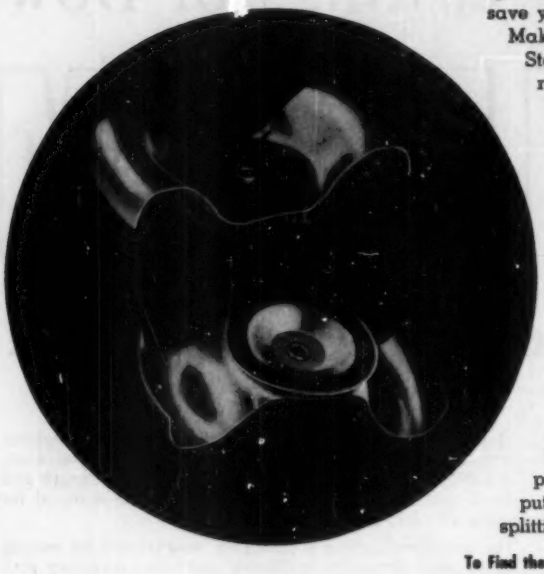
Cut costs, add sales appeal with Magnesium die castings

A leading camera manufacturer uses these magnesium die castings in his latest model. The accuracy of the castings cuts machining costs and makes assembly faster, more economical. The pleasing finish and the lightness obtainable only with magnesium add valuable sales appeal.

DOW

DOWMETAL

To Get BETTER FABRICATING RESULTS and REDUCED UNIT COSTS Change to *Carpenter* Stainless Strip!



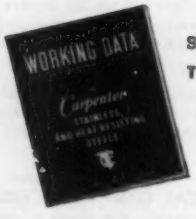
To get the physicals, finishes, tolerances and edges that save you money in production, do what this firm did. Make use of Carpenter's diversified experience with Stainless Strip. A call to your nearby Carpenter representative will help you get the most from every pound of Stainless Strip you use.

How Savings Were Made on This Stainless Job . . .

The Parts: Stainless shock absorbers to cushion glass linings in bottles.

The Problem: High rate of costly rejects because the tempered strip originally used would not take the severe forming required.

The Solution: Fabricating problems disappeared when Carpenter Stainless Strip (Type 410), tempered to minimum hardness of Rockwell C-40, was put on the job. No more trouble with cracking, splitting or spring-back of strip.



To Find the Carpenter Stainless Strip Best Suited to YOUR Job—
write for your copy of this 133-page book of information on Physical Constants, Mechanical Properties, Corrosion Resistance, Fabrication, etc. A note on your company letterhead will bring your copy of "Working Data for Carpenter Stainless and Heat Resisting Steels".

THE CARPENTER STEEL COMPANY, 117 W. Bern Street, Reading, Pa.
Export Department: 233 Broadway, New York 7, N.Y. "CARSTEELCO"

When You Want { Easier DRAWING / Easier FORMING / Easier BLANKING / Easier FINISHING }
be sure to use *Carpenter* Stainless Strip!

Carpenter

STAINLESS STRIP

WHEN YOU HAVE A STAINLESS PROBLEM—YOU CAN COUNT ON CARPENTER FOR THE ANSWER

Steam on the beam

with "built-in" G-E CALROD* HEATERS

*Reg. U.S. Pat. Off.

Heat where they want it!

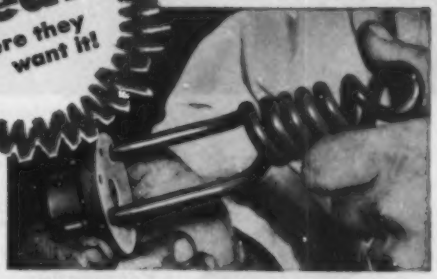
Madewell Products, Inc. puts steam on the beam in their Electro Spray with "built-in" G-E Calrod heaters!

Like hundreds of other machinery manufacturers, Madewell Products, of Oakland, California, have found that the simplest, easiest, most reliable way to build heat into their product is with G-E Calrod heaters. And in two years there hasn't been a single heater failure in the field!

Many times the heat source is a vital part of your machine. Because of the many types of G-E heaters... because of the wide range of standard sizes, ratings, and sheath materials in which these heaters are available . . . they provide a ready, practical solution to almost every conceivable problem of building low-cost, efficient heat into machinery.

Before You Design your machinery or equipment for repetitive manufacture, contact your nearest G-E Apparatus Sales Office and get the recommendations of an Industrial Heating Specialist . . . it will pay you BIG dividends. And . . .

FOR THE NEW, FREE 1950 CATALOG, GEC-1005A, write us on your letterhead. And, if you'll also tell us about your heating jobs, we'll send you application bulletins to help you select and correctly apply the right heaters to give you heat *where* you want it . . . *when* you want it . . . and in the *amount* you want it. ***Sect. 720-19, Apparatus Dept., General Electric Co., Schenectady 5, N. Y.***



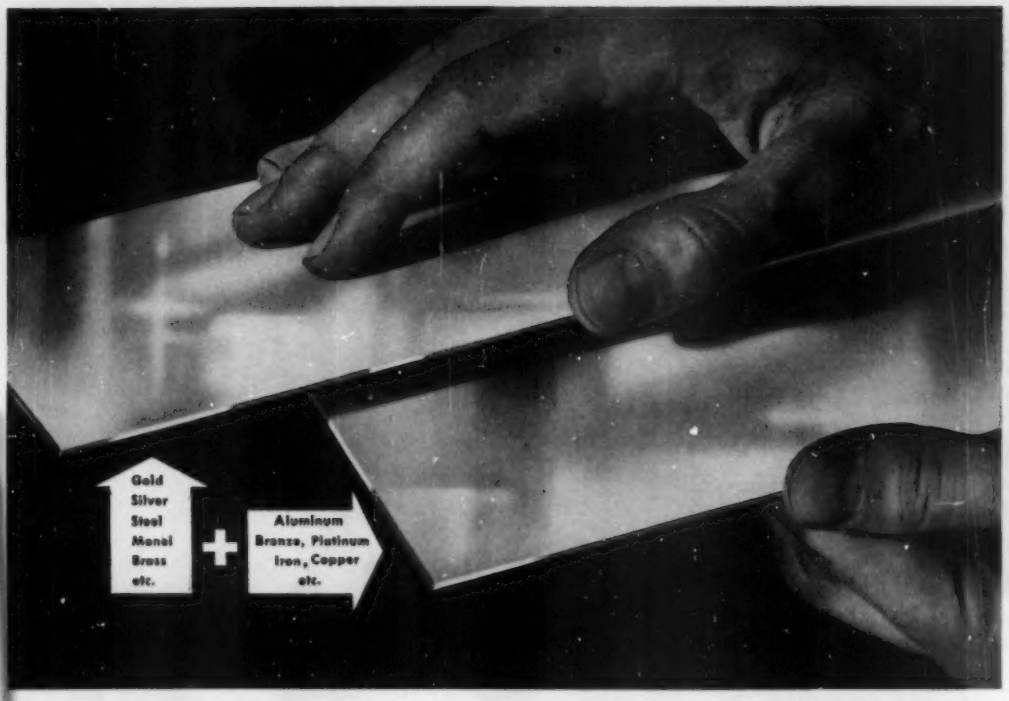
The Calrod heater is easily formed into a helical coil, cast into brass concentric to a $\frac{1}{2}$-inch copper-tube coil, and the compact unit acts as a flash boiler.

The Madewell Electro Spray, generates superheated steam which blasts particles of insecticide into the air for prolonged suspension with increased killing effects.

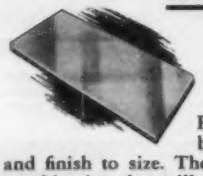
GENERAL ELECTRIC

720-19

TWO METALS
are often better than one



and GENERAL PLATE will bond the Right Combination for you



You name them—practically any two different metals and General Plate will permanently bond them together and finish to size. The result will give you a combination that will meet specific or unusual performance characteristics impossible to obtain in a single metal . . . often is more economical to use, easier to fabricate.

For example—General Plate Alcuplate, copper and aluminum, is used in terminations of aluminum conductors. This combination eliminates the electrolytic action which takes place in a "copper-aluminum" joint, as it provides for "alum-alum" joint on one side and "copper-copper" on the other.

Again, a Bismuth alloy (M.P. 165°F) was laminated with copper for a very special application.

General Plate also pioneered in the well-known silver inlay, edgelay and overlay on base metal which is widely used in contacts providing economical solid silver electrical performance at a fraction of the cost of the precious metal.

Regardless of the metals you are now using, it will pay you to investigate General Plate laminated metal combinations. Write, stating your problems and our engineers will work out a metal combination which may prove to be better than a single metal.

GENERAL PLATE PRODUCTS INCLUDE

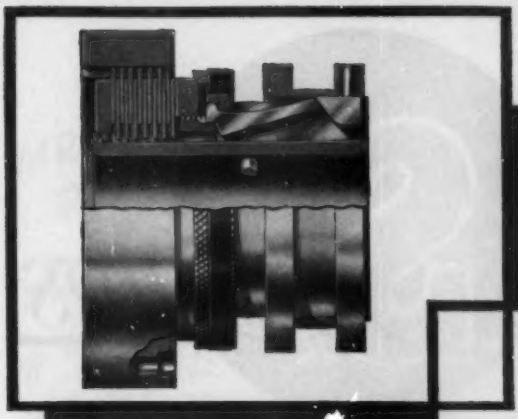
Truflex Thermostat Metals . . . Precious to base metal laminations . . . Base metal laminations . . . Alcuplate (copper and aluminum) . . . Silver solders . . . Laminated contacts, buttons, rivets . . . Platinum-fabrication-refining . . . Age-hardening Manganese Alloy 720.

GENERAL PLATE

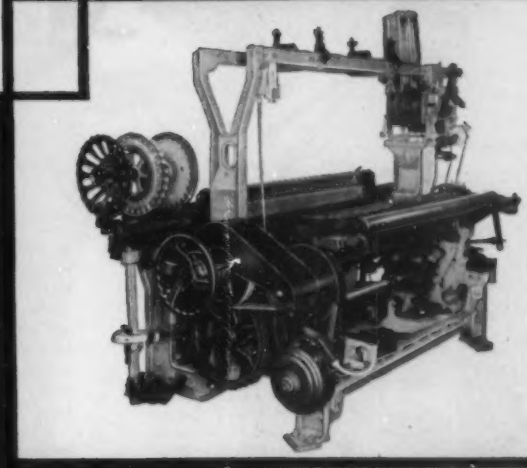
Division of Metals and Controls Corporation

105 FOREST STREET

ATTLEBORO, MASSACHUSETTS



MAXITORQ



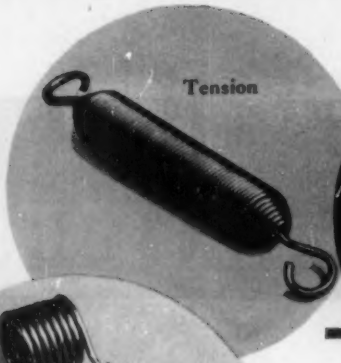
Keeps Good Company ...in the TEXTILE FIELD

The Maxitorq floating disc Clutch is now playing a new part in aiding Textile plants to cut production costs. Introduced by the H. F. Livermore Corporation, manufacturers of improved loom parts and accessories, a "package drive" unit is available for attachment to existing looms. The unit consists of two Maxitorq Clutches, one used as a drive, the other as a brake. Single units of either are also supplied. Thus the machine may be individually driven at today's high speeds . . . for greater output.

The compact, streamlined Maxitorq is original equipment with leading manufacturers of Machine Tools, Machines for Packaging, Mining, Labeling, Lumbering . . . for Trucks, Hoists, Sweepers, Mowers, etc. Its design is of utmost simplicity yet highly efficient within its capacity to 15 H.P. @ 100 r.p.m. "Floating discs" prevent drag, abrasion and heating. Clutches are shipped ready to slip onto a shaft, yet adjustment, take-apart and assembly are manual. Special Driving Cups, if desired, also Overload Release Feature.

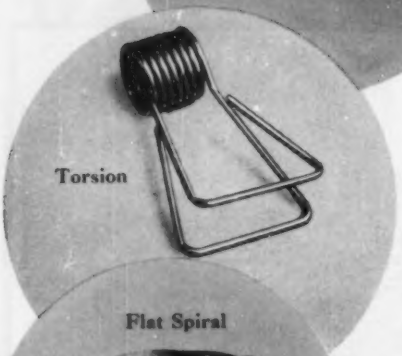
Send for NEW 1950 Catalog PE5

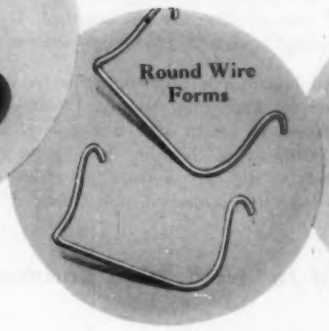
THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

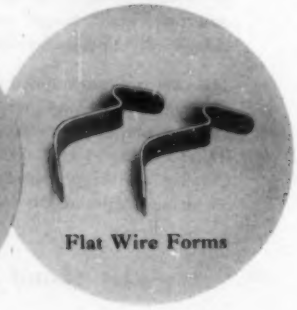


Springs

for every need







● No matter what type of spring you need, we can supply it . . . in the *quantity* you want . . . and *when* you want it.

Our American Quality Springs are made in all sizes and shapes—from giant coil springs to tiny open-wound helicals that weigh 5100 to the ounce. We can produce springs from round wire, shaped wire, flat wire or strip steel, from either pre-tempered or formed-and-then tempered material.

So whether you need springs of some special design, or some of the more common types, why not call on us?

Our engineers will help you get the right design and we can produce springs *exactly* as specified. A call or letter will bring one of our spring engineers to help you work out your spring problem.

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA STEEL COMPANY, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM, SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS AMERICAN QUALITY SPRINGS

UNITED STATES STEEL

MR. PRODUCT DESIGNER

Which properties of Lustrex styrene in this success story could improve your product... or lower your costs?

Monsanto also makes many other plastics and will recommend the one best suited to your needs.

Why not check with Monsanto today?

"We tenderized sales-resistance when we discarded habit-itis"

says

Wm. F. Spang
General Manager
Cube Steak Machine Co.
Needham Heights, Mass.

Housings of Cube Steak machines molded of Lustrex by Prolon Division, Pro-phy-lactic Brush Co., Inc., Florence, Mass. for Cube Steak Machine Company

"Now, our Cube Steak machines have a double-barreled sales advantage...because we eliminated habit-thinking in our research and production. Once we rejected the usual," continues Mr. Spang, "we eliminated headaches arising from chipped finishes; hard-to-get-at, hard-to-clean parts...with *new* housings made of Monsanto Lustrex styrene."

When the Cube Steak Machine Co. tossed out habit-itis, and replaced previous housings with ones of Monsanto Lustrex, they discovered how this durable, lightweight plastic could help them produce better, more sanitary machines...and win customer praise. For instance, they found the colorful finish of Lustrex goes all the way through—unlike painted surfaces, it can't peel, chip or wear off.

Housings of Lustrex are molded in *one* piece . . . are easily removed, by a flick-of-the-wrist, to get at operating parts instantly. Lustrex is smooth, and will not stain; and it is free from taste or odor. Best of all, this modern plastic is up to *nine* times lighter than some metals . . . provides more housings per pound, new savings in materials cost. Fast, *one-shot* production further lowers costs. And expensive assembling, machining, painting operations are eliminated or materially reduced.

Profit-wise manufacturers in *many* industries are banishing habit-itis in their plants...and are discovering new ways to improve old products, or to make new ones, while reducing manufacturing costs...with Lustrex, and other Monsanto plastics. How about your products? Your costs? It will pay you to send *today* for Monsanto's booklet, "What Monsanto Plastics Can Do For You." The coupon is for your convenience. Lustrex: Reg. U. S. Pat. Off.

MONSANTO
CHEMICALS—PLASTICS
SERVING INDUSTRY . . . WHICH SERVES MANKIND

For your convenience →

MONSANTO CHEMICAL COMPANY,
Plastics Division, Dept. PEP29, Springfield 2, Mass.
Please send me, "What Monsanto Plastics Can Do For You."

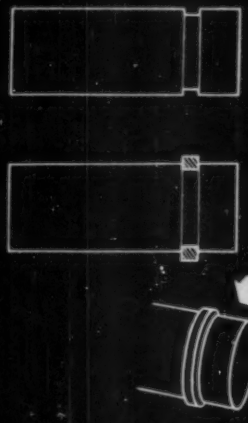
Name & Title _____

Company _____

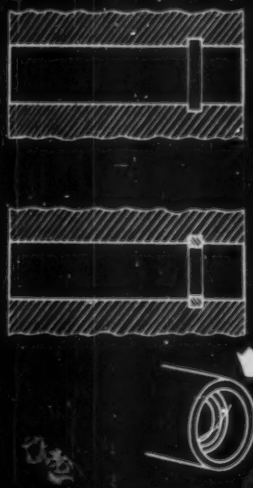
Address _____

City, Zone, State _____

ON SHAFTS



IN COUNTERBORES



STRONG SHOULDERS

in Seconds

Why buy steel to shoulder diameter and spend costly labor and time machining a shoulder . . .
when you can start with steel of the shaft diameter, machine a groove a few thousandths deep and slip a Reliance Ring into it?

Why drill to shoulder diameter and machine to bore diameter for a shoulder in a bore . . .
when you can just drill to bore diameter (or use tubing), machine a shallow groove and slip a Reliance Ring into it?

You can cut minutes to seconds and save labor and material cost.

Reliance Snap Rings are carefully heat treated and properly tempered to specifications. They are strong and are designed to withstand determined thrust loads.

Reliance Ring Engineers are at your service. Just write, phone or wire and they'll show you how Reliance Rings can cut the cost of your shouldered parts.

RELIANCE RINGS

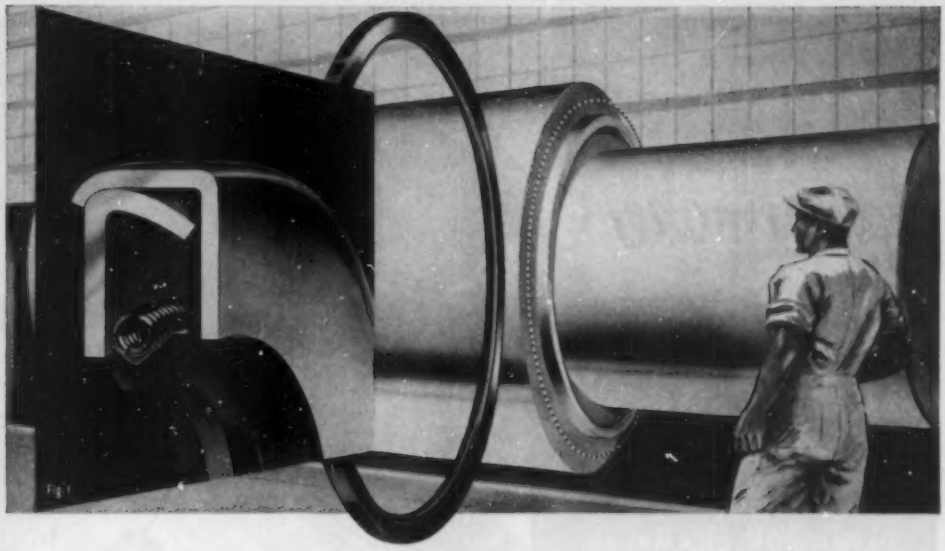
EATON

EATON MANUFACTURING COMPANY

RELIANCE DIVISION, MASSILLON, OHIO

Sales Offices: New York, Cleveland, Detroit, Chicago, St. Louis, San Francisco, Montreal

NATIONAL OIL SEAL LOGBOOK



where the going is BIG, rugged and hot... National Oil Seals meet a severe test

The high peripheral speeds and extreme ambient conditions encountered in main bearings of large rolling mills pose tough problems in bearing protection. The problem is aggravated by the presence of copious quantities of scale and the use of special coolants. Thus the actual sealing members of oil seals must in many cases be fabricated of materials which are impervious to breakdown when exposed to water and other coolants.

The National Oil Seal shown (Fig. 1) is successfully employed on the roll shafts of a large sheet steel mill machine. In this case the sealing member is made of National "Syntech"* synthetic rubber compound. The construction of the seal is identical to the basic National 50,000-S type used in hundreds of other applications. The seal itself is unusual in size since shafts on this equipment run between three to five feet in diameter while a section through the seal is under one inch. Close tolerance must be observed inasmuch as these seals must "press-fit" into the housing bore in the accepted manner and rugged construction is necessary to withstand rough handling when it becomes necessary to repair the equipment, which must of necessity be done hurriedly. Two such seals are utilized in each position: one to seal the lubricant in and the other to withhold contaminating extraneous matter which includes scale and coolant. This is done to effect economy in replacement.

These National Oil Seals provide efficient bearing protection despite the extraordinarily rugged surrounding conditions and the extreme peripheral speeds. Experience has shown that performance of this kind can be achieved without resort to special designs. This particular seal (Series 50,000-S type) is available in a wide range of sizes from dies already on hand. National Oil Seals engineers will be happy to consult with you on any bearing protection problem. Please write for additional information.

*Trade Mark registered

CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS

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DALLAS, TEXAS	30½ Highland Park Village, Justin 8-8453
DETROIT, MICH.	Room 1026 Fisher Building, Trinity 1-6363
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WEST SPRINGFIELD, MASS.	1025 Elm Street, Springfield 2-1881
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NATIONAL MOTOR BEARING CO., INC.

General Offices: *Redwood City, California*
Plants: *Redwood City and Los Angeles, Calif.; Van Wert, Ohio*

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If you make

THERMOSTATIC DEVICES
PRESSURE CONTROLS
HYDRAULIC MECHANISMS
VALVES
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RECORDING INSTRUMENTS,

You can make Savings with Sylphon Bellows Assemblies

THESE ARE JUST A FEW of the ways in which Sylphon bellows assemblies are used. There are many more—where there are design problems involving temperature or pressure control. Wherever you use them, Sylphon bellows assemblies help you make savings that really count up!

For example, when we produce them for you, you save time. You get your bellows assemblies *on schedule*. Another saving—you have less overhead and production costs. We have ample facilities—trained personnel—geared to produce in volume quantities. What's more, you save product "troubles", because we produce assemblies made *exactly* to your specifications.

Whatever type of bellows assembly you need, simple or complex, in brass, stainless steel or other metal, we can make as you want it. It's a specialty with us—has been for forty-six years. And it *takes* specialists to produce bellows assemblies that are accurate, dependable and rugged.

Find out how you can save on your bellows assemblies requirements. Send in your specifications or ask for helpful engineering service. Write today. Ask for free Bulletin JP-1200 that gives complete information.

TEMPERATURE CONTROLS

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BELLOWS ASSEMBLIES • BELLOWS DEVICES

THESE RUGGED LIGHTWEIGHTS
ARE CHAMPIONS IN THEIR CLASS

Specify

BENDIX-SCINTILLA

THE MOST TRUSTED NAME IN MAGNETOS

Today's small engine buyers have become more and more demanding in their standards of quality—with the factors of dependable starting, economy of operation, long life, and freedom from breakdown given foremost consideration. It is the ability of Bendix-Scintilla magnetos to serve these needs *better in every way* that makes them champions in their class. These rugged lightweights are your best bet to step up performance and sales appeal—for their basic design guarantees quality performance for *every type* of small engine and *every pricing* requirement. In both original equipment and field replacement, give your outboard motors, small industrial and marine engines championship performance by insisting on the most trusted name in magnetos—Bendix-Scintilla.

BUILT-IN RELIABILITY

Simplicity in design • Waterproof condenser and coil • Lower operating cost • Minimum lubrication requirements • Light in weight • Higher voltage at starting speeds • Constant spark over entire speed range • Compact and sturdy construction.

SEE OUR EXHIBIT AT THE HOUSTON INDUSTRIAL EXPOSITION, MAY 10 THRU 14, 1950

BENDIX SCINTILLA

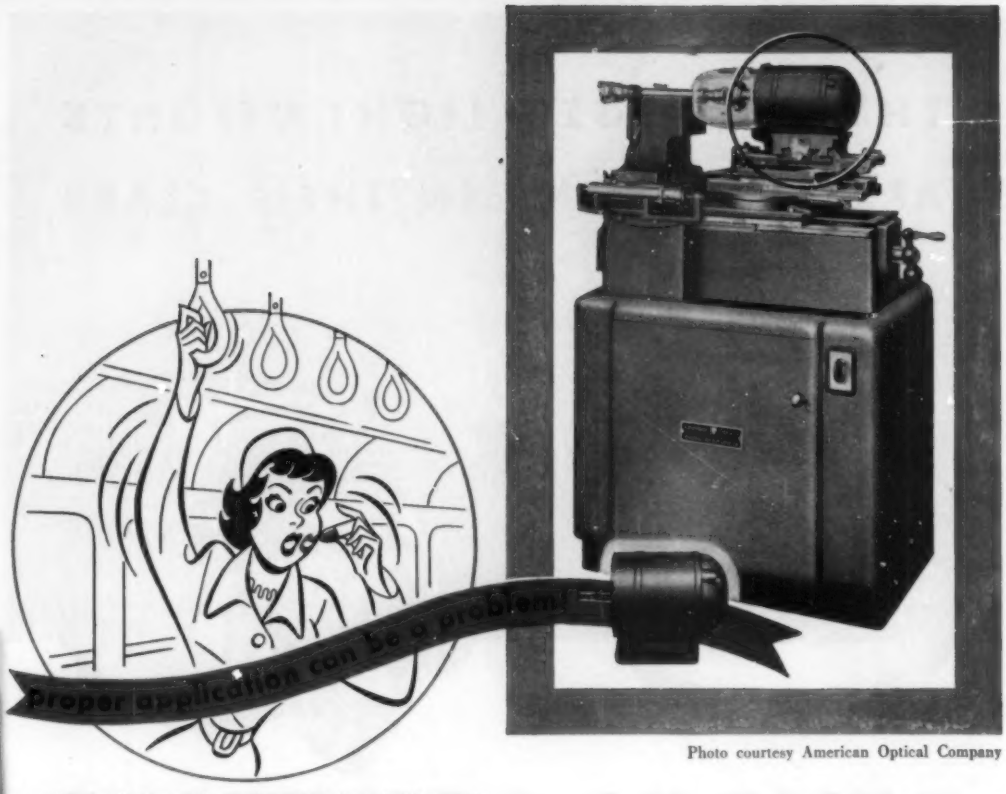


Photo courtesy American Optical Company

. . . take, for instance, the engineering of a suitable small motor for American Optical Company's M405 Universal Micro-Surfacer. This revolutionary optical machine, designed to smooth-grind the concave surface of lenses, demanded most exacting specifications for the motor unit to be used in driving the diamond lap spindle.

- The motor must be totally enclosed, to exclude dust and grinding compounds.
- The motor must be adaptable to a machine bed, similar to a lathe bed.
- Tolerances on center line to base dimension and all parallel tracking surfaces must be held to an absolute minimum, for purposes of interchangeability.
- Parallelisms must be held to an absolute minimum to insure a true running spindle.
- Spindle must have absolute minimum of endplay and runout.

After thorough analysis and study of the problem, Holtzer-Cabot engineers designed a precision motor that not only met all customer requirements, but *was priced competitively.*

This Holtzer-Cabot motorized unit, supplied in various frequencies and voltages as well as in Direct Current, is now being used extensively.

Our files are filled with success stories like this. The application solution described here is just one of many examples of Holtzer-Cabot's versatility and ability to meet customers' most rigid specifications. Holtzer-Cabot motors range from 1/2000 up to 1 H. P.; from 24,000 RPM to 1 revolution per day!

HOLTZER-CABOT

DIVISION OF NATIONAL PNEUMATIC COMPANY INC.

BOSTON 19, MASSACHUSETTS

OFFICES IN NEW YORK, PHILADELPHIA and CHICAGO

GOT AN APPLICATION PROBLEM?

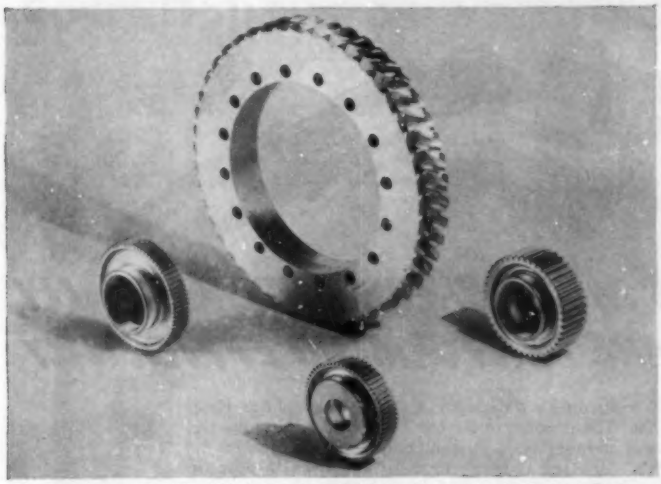
If *you* have an application problem involving motors up to 1 H.P., turn to Holtzer-Cabot for the solution. We are eager to tackle the most difficult motor problem. Write for complete information.

builders of fine electric motors for three-quarters of a century

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by BRIDGEPORT BRASS COMPANY "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*



Worm wheel of Duronze III, 11½ in. diameter and 1½ in. wide, used in mill lift truck. Three spur gears for drilling and tapping machines manufactured by Bodine Corp., Bridgeport, Conn.

High Strength, Smooth Operation Found in Duronze Gears, Screws

High strength, smooth, hard bearing surfaces, and ability to withstand corrosion and wear are demanded of many functional parts. When ferrous metals are selected for such parts, the cost of machining rises considerably due to low surface speeds and feeds necessary to obtain good finish and satisfactory tool life.

Silicon aluminum bronze, Duronze III, answers the product designer's demands for high functional qualities and at the same time eases the problems of the tool engineer and production department by its good machinability.

Duronze III Worm Wheel Outlasts Cast Bronze Gear

Duronze III was used in the illustrated worm wheel, spur gears and wedge adjusting screw. This alloy contains about 91% copper, 7% aluminum and 2% Silicon and has a tensile strength between 85,000 to 90,000 pounds per square inch in the annealed condition. It has a machinability rating only 40% less than free machining brass rod.

The ability of Duronze III to give long life under heavy loads as compared to cast bronze, is evidenced in the worm wheel used in a mill lift truck. The Duronze wheel was installed in 1945 and is still in good shape for longer service. Other Duronze gears in these lift trucks have been in for several years with no great sign of wear. The cast bronze gear (original equipment) lasted less than two years.

Smooth Reversing Spur Gears

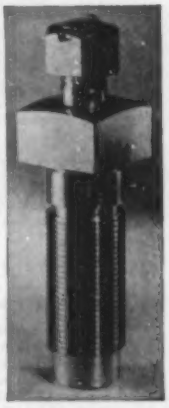
Constant forward and reversing motion is essential in Bodine's special drilling and tapping equipment. Duronze is successfully used for the spur gears on the tapping heads. The gears illustrated were manufactured by forging the blank, turning, drilling, boring and tapping as well as cutting the teeth. Surface speeds ranging from 150-250 fpm are possible with high-speed tools and much higher with tungsten carbide tips.

Valve Screw for Hoover Dam

Pawtucket Manufacturing Co., Pawtucket, R. I., used Duronze III for wedge adjusting screws to be used in butterfly valves controlling the flow of water into the turbines generating electricity at the Hoover Dam. High corrosion resistance was easily answered, but the physical demands for these screws were another thing:

1. Ultimate tensile 90,000 psi.
2. Yield point in tension 50,000 psi.
3. Reduction in area 15%, and
4. Elongation in 2 inches 15%.

Bridgeport supplied Duronze III in 2¼ inch square rod. The screw has a thread 1¾ inches diameter with eight threads to the inch. A smooth-running fit is essential as well as accuracy and finish on the turned diameters.



Wedge adjusting screw made by Pawtucket Manufacturing Co., Pawtucket, R. I., for butterfly valve at Hoover Dam. Stock was 2¼ in. square Duronze III rod with tensile strength of 90,000 pounds per square inch.

Another factor which the designer cannot overlook is weight. Duronze III is 10% lighter than competitive silicon bronzes, representing a substantial saving in cost.

Bridgeport's Laboratory will supply engineers with additional information on Duronze III alloy or help you to select the correct alloy to meet your specific needs. Write for the Duronze Manual.

BRASS · BRONZE · COPPER · DURONZE — STRIP · ROD · WIRE · TUBING

MILLS IN
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In Canada:
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BRIDGEPORT BRASS COMPANY
BRIDGEPORT 2, CONNECTICUT
Established 1865
"Bridgeport" *District Offices and Warehouses in Principal Cities*

WHEREVER LINES MUST BREAK AUTOMATICALLY
INSTOMATICS ARE PERFORMING EFFICIENTLY

Fuel lines to drop tanks on the B-36 are fitted with WIGGINS Inst-O-Matic couplings. Here, human hands cannot separate the line. The coupling must break automatically, positively; and the fuel in both lines must be sealed off instantly. In this, and other applications where the flow of fluids or air must be broken, WIGGINS Inst-O-Matic couplings are proving their worth.

Now, these couplings are available with required lengths of INST-O-FLEX, a smooth woven, flexible metal hose that guarantees protection against abrasion and kinking. High quality neoprene rubber liner makes INST-O-FLEX impervious to oil, water, gas and gasoline.

CONSTRUCTION:

Smooth woven, galvanized steel outer wall. Also available in copper, brass, stainless steel and monel. Suitable liners for special applications.

I.D. SIZES: ¼", ⅜", ½" and ⅝".

WHAT IS YOUR MOTION PROBLEM?

If you work with, or design machinery, industrial equipment or domestic appliances that must be periodically moved; or if you are concerned where articulated motion, vibration or make-and-break connections must be accommodated, INST-O-FLEX assemblies are big engineering news. Write for complete details today.

P-1707 valved socket ⅛" F.P.T.

Ever alert to progress, *Scott-Atwater* provides an auxiliary fuel tank for their new 1950, 1-30, 16 HP TWIN outboard motor unit. WIGGINS standard P-1700 series, self-sealing Inst-O-Matic coupling is specified on the fuel line to insure speed of operation and a leakproof connection.

Wiggins

Write for name of nearest representative or
E. B. WIGGINS
OIL TOOL CO., Inc.,
3424 E. Olympic Boulevard,
Los Angeles 23, Calif.
Telephone ANgelus 7238

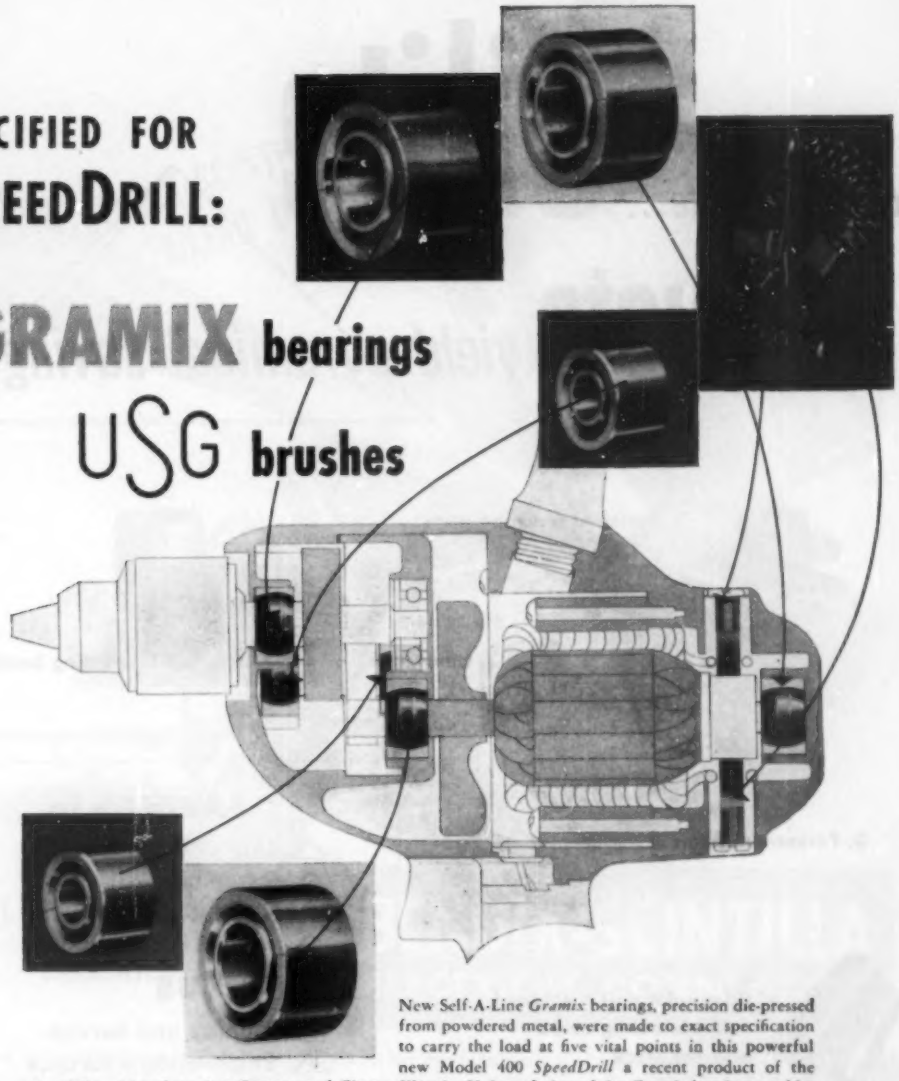
INSTOMATIC COUPLINGS

INSTOFLEX WOVEN METAL HOSE

SPECIFIED FOR SPEEDDRILL:

GRAMIX bearings

USG brushes



New Self-A-Line *Gramix* bearings, precision die-pressed from powdered metal, were made to exact specification to carry the load at five vital points in this powerful new Model 400 *SpeedDrill* a recent product of the SpeedWay Manufacturing Company of Cicero, Illinois. Unique design of the *Gramix* bearings enables them to maintain steady alignment of the drill shafts and to absorb the thrust load under hardest operating conditions. The self-lubricating features of Gramix eliminates need for regular oiling, and the great durability of these bearings makes for long life in any application. Teamed with *Gramix* in the *SpeedDrill* are two special USG carbon brushes which will furnish positive balance of brush pressure on the commutator at all drill speeds.

Send your prints to us — our engineers will be glad to make recommendations without obligation. Write for the new *Gramix* and USG Brush catalogs.

GRAMIX

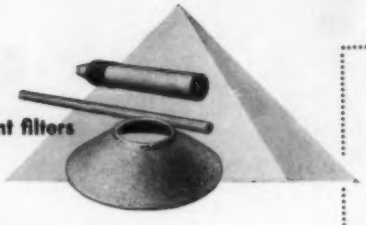
THE UNITED STATES GRAPHITE COMPANY, SAGINAW, MICH. DIVISION OF THE WICKES CORPORATION

Customers state... **Oilite**

Products *yield pyramidal savings...*

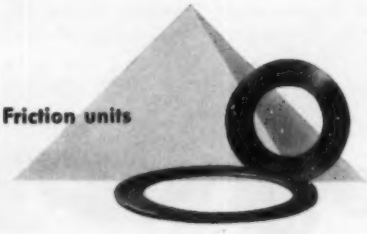
1. Finished machine parts

2. Heavy-duty oil-cushioned, self-lubricating bearings



3. Permanent filters

4. Heavy-duty oil-cushioned, self-lubricating cored and bar stock



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Contact your local Oilite field engineer or home office

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HAMILTON STANDARD and FAIRCHILD rely on

BENDIX-SCINTILLA
ELECTRICAL CONNECTORS

Unfailing dependability is one of the requirements set by Hamilton Standard and Fairchild in their selection of equipment. The installation of Bendix-Scintilla electrical connectors in vital circuits of Hamilton Standard propellers is, therefore, a tribute to a fine product.

Wherever circuits must be arranged to connect and disconnect with ease and certainty, Bendix-Scintilla is the choice. Remember that whenever there is no compromise with quality, it pays to specify Bendix-Scintilla electrical connectors—the finest money can buy!

Write our Sales Department for detailed information.

CHECK THESE ADVANTAGES

- Moisture-proof
- Radio Quiet
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- Vibration-proof
- Lightweight
- High Insulation Resistance
- Easy Assembly and Disassembly
- Fewer Parts than any other Connector
- No additional solder required
- Approved A-N source

SEE OUR EXHIBIT AT THE HOUSTON INDUSTRIAL EXPOSITION, MAY 10 THRU 14, 1950

BENDIX SCINTILLA

SCINTILLA MAGNETO DIVISION of SIDNEY, N. Y.

Bendix AVIATION CORPORATION

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, N. Y.

Wallace Barnes Springs

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Why are E D motors extra dependable?

E. D. DRIP PROOF INDUSTRIAL MOTOR
for use under ordinary industrial conditions not requiring protection from splashing liquids or from atmosphere laden with dirt or metal chips.

SPLASH PROOF
For installation where the motor is subjected to splashing liquid or hosing down for cleaning.

TOTALLY ENCLOSED
(Fan Cooled)
For use in dirt-laden atmospheres, especially where the installation requires a motor of compact dimensions.

TOTALLY ENCLOSED
(Non-Ventilated)
For use in exceptionally dirty atmospheres, particularly when metallic dust is present.

Because extra care goes into their windings —"The Heart of the Motor"

E. D. Manufacturing Skill and Superior Insulation Bring You Long Service, Great Dependability

At Electro Dynamic, the secret of making tough, dependable motors has been learned through 70 years of meeting and surpassing the rigid standards set by naval engineers and architects. The same proven manufacturing principles are applied in building today's E. D. *industrial* motors.

Now you can benefit from the special skill, the extra care and superior insulating materials that go into E. D. windings . . . the rugged construction of E. D. frames. You'll be amazed at the stamina and unfailing dependability of these fine motors. You'll be surprised that E. D. motors are competitively priced!

Get all the facts on famed Electro Dynamic motors today. Write for illustrated literature.

Also a Complete Line of DIRECT CURRENT
Motors and Generators. Literature on Request.

Industry has learned what marine engineers have known since 1880

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ELECTRO DYNAMIC • Division of the Electric Boat Company • Bayonne, N. J.

Can You Use a HEAVY liquid?

Can you use a heavy liquid that has contributed greatly to simplifying design and fabrication of certain products?

Acetylene tetrabromide is an unusually heavy liquid with a specific gravity of 2.95. It is stable in dry air in the absence of sunlight and, when sealed in an opaque container, will not break down.

Acetylene tetrabromide is comparatively inexpensive and finds wide use as a gauge fluid and as the movable part in vibration dampeners.

GIVE A SEARCHING LOOK at the properties of acetylene tetrabromide. Then, if you desire further information or technical service, write or wire Dow.

$C_2H_2Br_4$

Properties:

Clear, colorless liquid with a mild sweet odor.

Specific gravity at 25/25°C.	2.953
Pounds per gallon at 25°C.	24.57
Boiling point at 15 mm. Hg	119°C.
Freezing point	0.0°C.
Fire point	None
Flash point	None

Solubility, grams per 100 grams solvent:

Alcohol at 25°C.	∞
Carbon Tetrachloride at 25°C.	∞
Chloroform at 25°C.	∞
Ether at 25°C.	∞
Water at 30°C.	0.065
Water at 80°C.	0.28

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Send for free sample of ACETYLENE TETRABROMIDE

The Dow Chemical Company
Dept. 3-H
Midland, Michigan

Name_____ **Title**_____

Company_____

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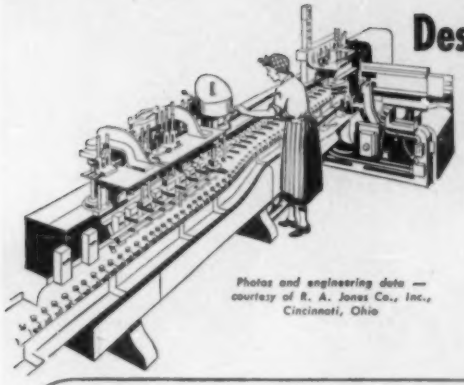
INDISPENSABLE TO INDUSTRY AND AGRICULTURE

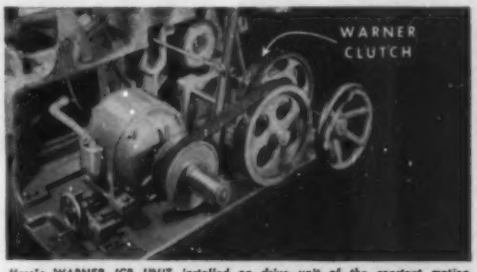


Photos and engineering data — courtesy of R. A. Jones Co., Inc., Cincinnati, Ohio

Designers of new automatic cartoning machines use WARNER ICB UNITS to get "smoother starting torque, closer balance of overload torque and faster stopping."

IF YOUR PROBLEM

is to design your machine or its activating parts so that *you get:* (1) Push-button actuation at the machine or a remote control panel. (2) Fully or semi-automatic operation in "stop" or "start" of machine cycles. (3) Controlled acceleration or deceleration. (4) Automatic or manual adjustment of torque to load . . . or if your problem is *to eliminate:* (1) "Shock" from stop or start on gear trains and shafts. (2) Complex mechanical lever linkage, or air and hydraulic piping systems. (3) Vibration and hammering from solenoid operated brakes and clutches . . . or if you want to *increase production* from your machine by increasing the speed and number of cycle operations —



Here's WARNER ICB UNIT installed on drive unit of the constant motion vertical cartoner. ICB Unit improved machine performance and easily replaced manual clutch and solenoid operated brake. Eliminated "coasting" problem.

A GOOD SOLUTION

to any one or combination of these problems is WARNER ICB Units. WARNER ICB Units are electrically controlled and operated clutches and brakes. They are compact, mechanically simple and may be applied to machine spindles, drive shafts, or direct to electric motors. Because of their design, they may be operated individually or in combination, manually or automatically, by direct or remote control. They provide for infinite controlled variation of torque in either clutching or braking action within their rated capacities. Their action is smooth and shockless—fast and practically noiseless. They are self-adjusting and self-compensating for life. Their design guarantees a high rate of heat dissipation.

From left to right: a Warner ICB Brake Unit, a Warner ICB Clutch Unit, and a combination Warner ICB Clutch and Brake Unit. Note clean, smooth, compact, appearance — simple mechanical parts.

MORE INFORMATION

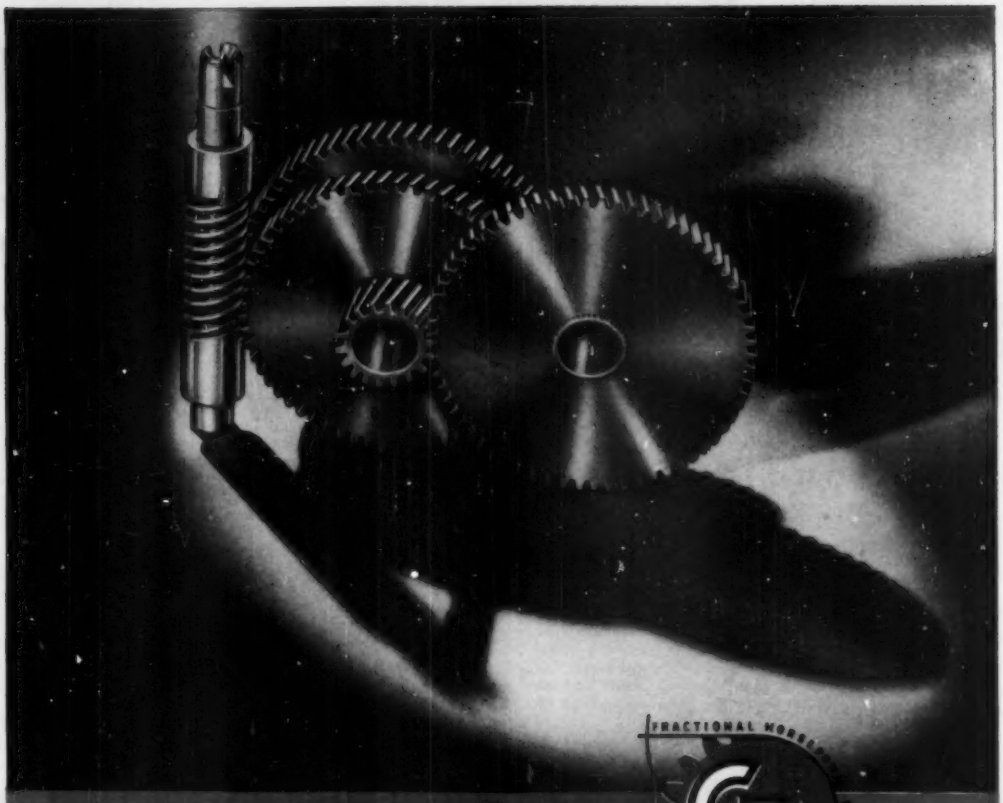
You can get detailed information on practical job applications of Warner ICB units. We will be glad to show you actual case histories of proven applications on a big variety of machinery. There's a complete range of sizes to meet wide requirements. Write today for bulletin 701. If possible, state your problem. Experienced Warner engineers will consult with you without obligation.

Warner Electric Brake Mfg. Co.
Beloit, Wisconsin

Bulletin 701 contains complete specifications and description of WARNER ICB Units. See for yourself how they offer advantages never before available on industrial clutches and brakes. Write for it today — no charge.

WARNER
ICB UNIT

WARNER ICB Units are manufactured by Warner Electric Brake Mfg. Co. — pioneers in the field of electric brake design and application since 1927.



FRACTIONAL HORSEPOWER GEARING

GS

DEPENDABILITY OR *DEATH!*

THE MONAGHAN . . . *"world's most modern chest type portable Respirator"* . . . MUST operate with never-failing dependability! For, failure can mean death! Is it any wonder, then, that the J. J. Monaghan Company of Denver is *extremely particular* about the gears and other components parts they buy? The complete set of precision-cut G.S. Gearing pictured above is used in their speed reduction unit. Produced to meet the most exacting specifications, this better G.S. Gearing assures smooth, quiet, dependable performance, *always.* ☆ If *better* Fractional Horsepower Gearing is an essential requirement, by all means *consult our Small Gear Specialists.* Join the host of discriminating buyers from coast-to-coast who depend upon us for the kind of service and satisfaction they need. Ideas, suggestions and cost estimates cost you nothing. Send along your drawings and specifications, or write for the free G.S. Catalog-Data Book, TODAY!

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Spurs • Spirals • Helicals • Bevels • Internals • Worm Gearing • Racks • Thread Grinding

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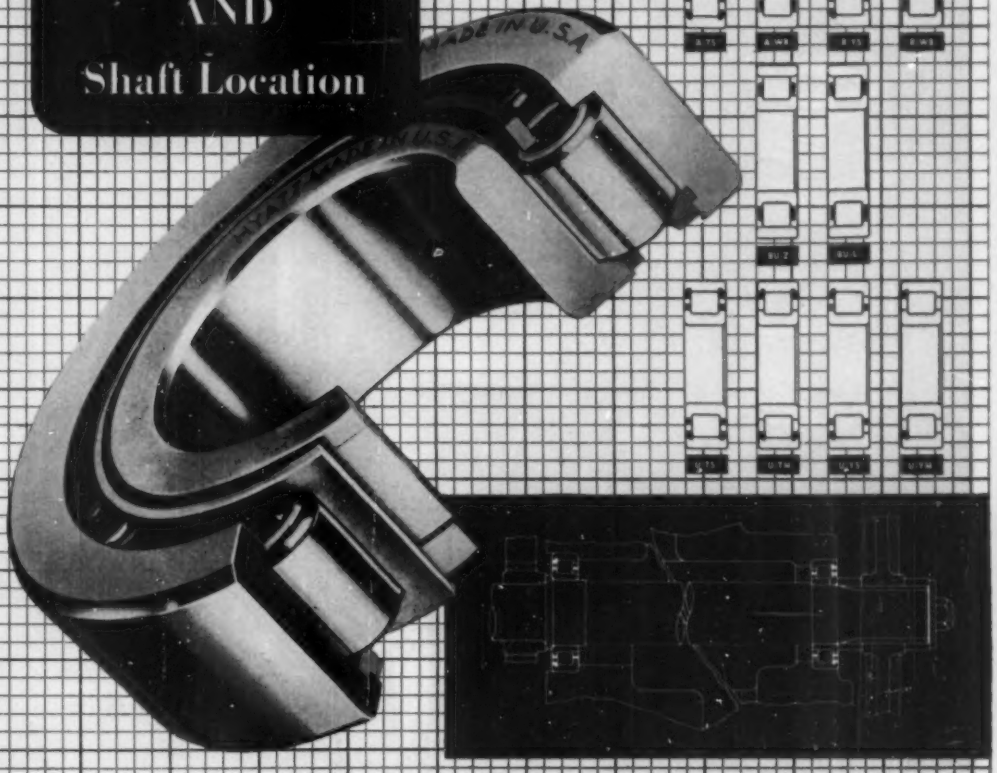
WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

Hy-Load Capacity AND Shaft Location



The cut-away bearing illustrated is an "R-YS" type Hyatt Hy-Load Bearing. It not only provides the high radial capacity of a cylindrical roller bearing but when mounted in pairs, opposed as shown in the drawing above, will also locate shafts.

In the Hyatt Hy-Load line of cylindrical roller bearings there are ten different types, each designed to fulfill specific application needs. Of these ten types, four are made with separable inner races, two with separable outer races and four are non-separable, thus permitting wide flexibility in machine design and assembly procedures. A wide range of sizes are made in every type.

With this large selection of bearing types and sizes from which to choose, a designer can find a Hy-Load Bearing to fit almost any application need.

• • •

Full information about Hyatt Hy-Load Roller Bearings is contained in our Catalog 547 . . . a complete engineering guide to radial bearing selection and use. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

The picture above shows just a few of the many bellows assemblies that are made to order by Clifford for leading firms. Hydron Bellows Assemblies perform many different functions, such as:

- Actuating switches or valves for accurate control of temperatures and pressures.
- Sealing rotary shafts against leakage of liquid or gas.
- Providing a flexible joint for instruments combining rotary motion and hermetic seal.
- Transmitting movement hydraulically to remote points.

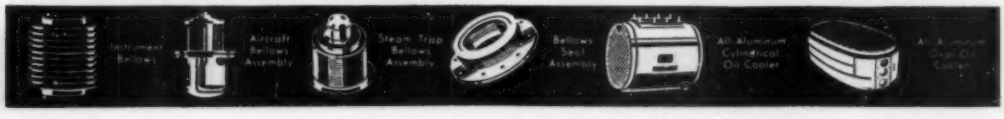
Why not investigate to see what Clifford bellows assemblies may do for you? Our engineers will be glad to make a confidential analysis of your sketches and specifications. No obligation, of course. Just write: CLIFFORD MANUFACTURING COMPANY, 122 Grove Street, Waltham 54, Mass. Division of *Standard-Thomson Corporation*. Offices in New York, Detroit, Chicago, Los Angeles.

HYDRON

CLIFFORD

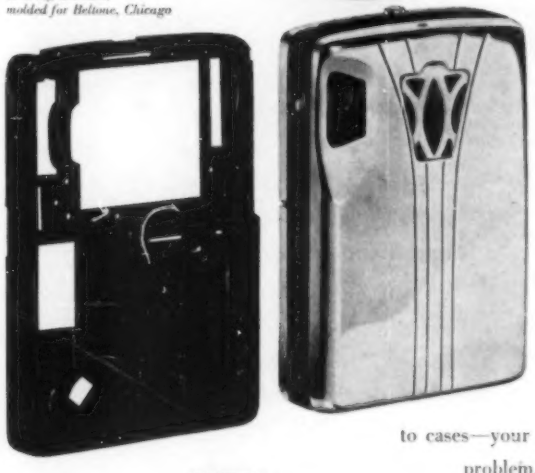
HYDRAULICALLY-FORMED BELLOWS AND BELLOWS ASSEMBLIES

ALL-ALUMINUM OIL COOLERS FOR AIRCRAFT ENGINES



Skillful Molding Presents a Fine Case for Better Hearing

Hearing aid case, molded for Beltone, Chicago



You can get a lot of help for your plastic problems from our plastic case histories. Take this Beltone hearing aid case for example. Here is compactness, durability and attractive modern design. Look carefully and you can also see some intricate interior work that required precision tolerances in molding. We've also molded a wide variety of other plastic cases—small cases—large cases—simple cases—complex cases. Each solved a distinct problem while increasing product appeal.

Let us put this experience at your profitable disposal. Just tell us today when we may get down to cases—your cases, or any other injection molding or extrusion problem. Our assistance is yours without obligation.

Write on your letterhead for the new Injection Molded and Extruded Plastics Catalog. Or, for detailed information about CHEM-O-LOY® piping, tubing and fittings, write for circulars containing data and illustrations.

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WHITNEY ROLLER CHAIN

Helps the "Trench-Hog"

Take a Full Bite

The "Blackhawk Trench Hog", manufactured by the Arps Corporation, digs trenches up to 7 feet deep and 20 inches wide in record time. At depths of 3′ to 4′ and 6″ to 8″ wide, it digs a trench at 300′ to 400′ per hour. That's traveling . . . and the cutting blades and roller chain have to travel too.

In the "Trench Hog", Arps Corp. secures its high carbon cutting blades on tough, rugged 2″ pitch Whitney Roller Chain. Despite the high shock loads when rocks and other obstructions are encountered, the Whitney Roller Chain keeps performing day in, day out. Positive grip assures full transmission of power to the cutters.

The "Trench Hog" application is a typical example of the versatility and adaptability of Whitney Roller Chains for meeting special requirements. There is practically *no limit* to the range of applications for material handling available through the use of standard or special attachments. The all steel roller chain construction provides long life.

Whitney chains . . . roller, silent, conveying . . . are quickly available through the nation-wide net-work of Whitney Distributors and warehouses. Consult the one nearest you for prompt, efficient service. For catalog or specialized chain engineering assistance write:

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Power Line
ROLLER CHAIN DRIVES

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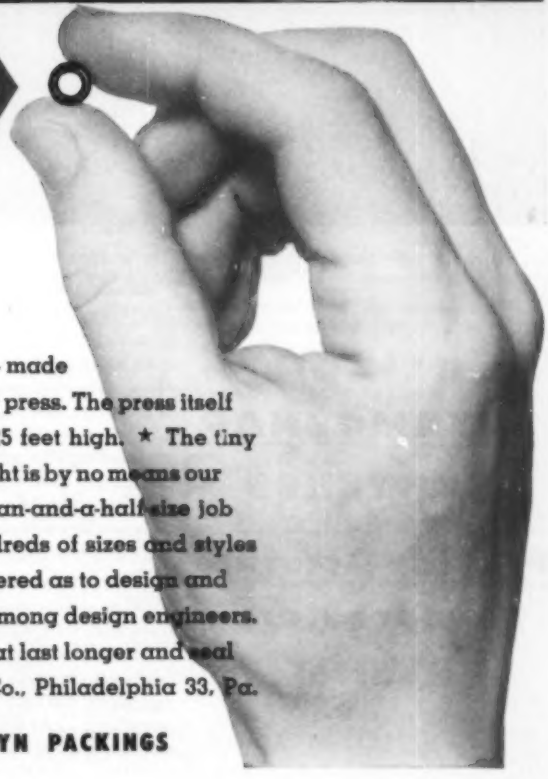
- Flexible Couplings — for positive but flexible direct drives
- Cut Tooth Sprockets — for smooth engagement, long life
- Whitney Woodruff Type Keys — for greater strength, easy assembly

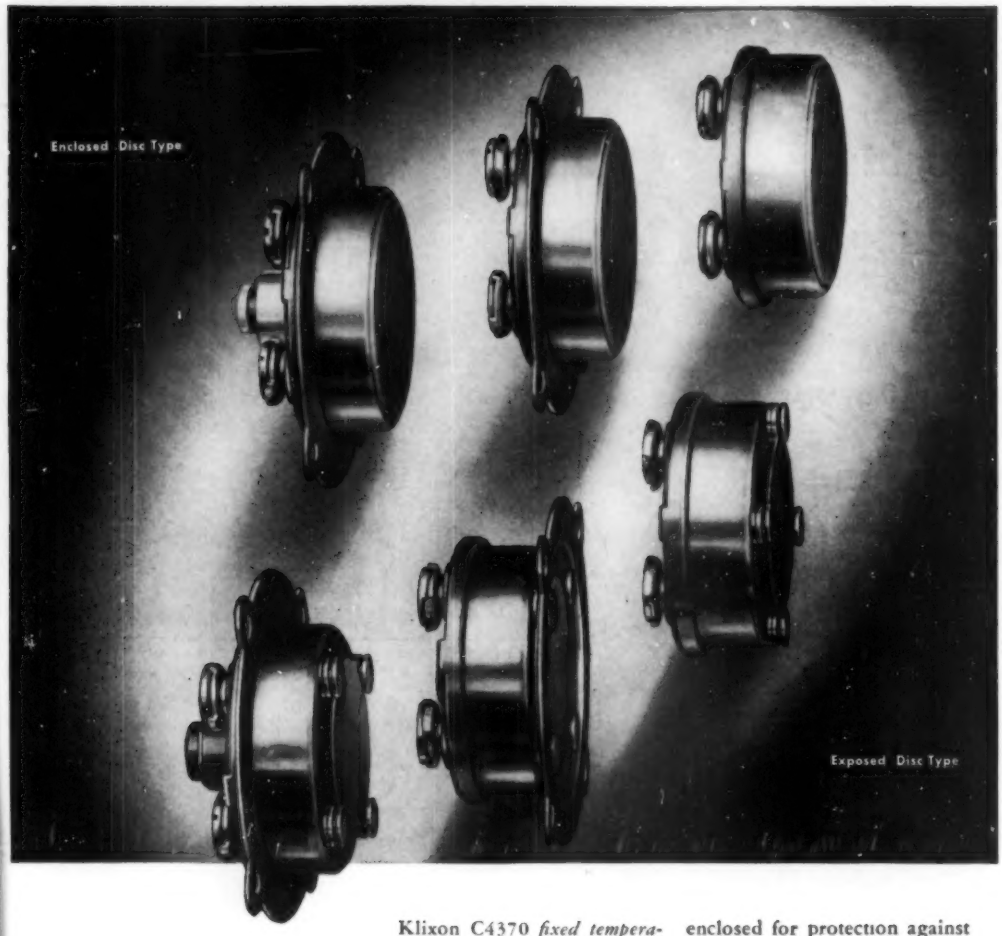
Houghton packings, from year to year, range in size from HERE TO HERE



and they're backed by years of designing "know-how"

The 91-inch "U" shown above is one of Houghton's largest one-piece packings — made for an air-operated clutch on a hot-forging press. The press itself weighs nearly half a million pounds, is 25 feet high. ★ The tiny ¼-inch "O" ring held in the hand at the right is by no means our smallest, but it vividly contrasts to the man-and-a-half-size job above it. ★ Both packings, and the hundreds of sizes and styles between those extremes, are fully engineered as to design and application. That's why we rate so high among design engineers. And it's why, when you want packings that last longer and seal better, you'll contact E. F. Houghton & Co., Philadelphia 33, Pa.

HOUGHTON'S VIM LEATHER & VIX-SYN PACKINGS



KLIXON THERMOSNAP SWITCHES

Provide Accurate Temperature Control

Klixon C4370 *fixed temperature* Thermosnap Switches give accurate temperature control in such equipment as space heaters, sterilizers, electrical appliances, small water heaters, unit heaters and other products. Actuated by the scientifically calibrated Spencer Klixon Disc, they open with a quick clean break; close the circuit with a fast solid make.

Klixon Thermosnap Switches can be supplied in various temperature differentials in settings from minus 10° to 550°F. These control units are available with enclosed contacts and exposed operating disc for fast thermal response . . . or with both contacts and thermal disc completely enclosed for protection against dirt, dust, oil, etc.

Klixon Type C4370 Controls are listed by Underwriters' Laboratories for use where proper terminal enclosure is provided. This eliminates further testing of the thermostat when applied to products requiring Underwriters' listing.

Write for complete information today.

KLIXON

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Division of Metals & Controls Corp.
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NOW Line-O-Power

STRAIGHT LINE DRIVES

DOUBLE REDUCTION

TRIPLE REDUCTION

high quality
economy
efficiency

CHECK THESE Line-O-Power features

✓ **ECONOMICAL TO BUY**—Lower original cost because these units are designed for manufacture on latest and most accurate high production machine tools.

✓ **ECONOMICAL TO OPERATE**—Straightforward, enclosed offset shaft principle of design gives efficiencies of 96% or higher. Simplified construction—minimum number of moving parts—direct splash lubrication—quality workmanship hold maintenance to a minimum.

✓ **DUTI-RATED HELICAL GEARS**—Duti-Rated high hardness helical gears manufactured to rigid standards assure exceptional accuracy, long life and dependability.

✓ **MODERN APPEARANCE**—The last word in clean-looking, modern design. The streamlined Line-O-Power unit on original equipment highlights the designer's approach to functional, efficient equipment.

✓ **COMPACT — SAVES SPACE** — Compact because the entire housing volume has been utilized to attain speed reduction. Placement of input and output shafts in a direct line brings the coupled motor and speed reducer into a narrow line of power transmission.

✓ **LARGE OVERHUNG LOAD CAPACITY**—Conservatively selected, large capacity antifriction bearings and husky output shafts assure maximum overhung load capacity.

✓ **STURDY HOUSINGS**—The housings of Line-O-Power Drives are rugged, dense, sturdy castings to give maximum rigidity and minimum deflection under load.

✓ **LARGE RANGE OF SIZES AND RATIOS**—A large range of double and triple reductions for capacities from 1 to 200 horsepower. Ratios from 5 to 1 up to 238 to 1 available for prompt delivery.

✓ **APPLICATION ADAPTABILITY**—Line-O-Power drives will transmit power from any prime mover and are adaptable for horizontal side-wall or ceiling mounting upon order.

Here is a newly developed drive that offers high quality combined with economy both in original cost and in operation.

Line-O-Power Units use Foote Bros. Duti-Rated high hardness helical gears for long life, quiet operation and compactness.

Line-O-Power Drives are the last word in modern symmetrical design. Wherever enclosed gear drives are used, they assure a clean-cut, efficient power package unit.

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VICKERS HYDRAULICS

The Model 406 is a prominent member of the family of Buckeye Ditchers described as providing "The Most Ditch for the Least Money." It has a reputation for fast digging, stamina and versatility. The telescoping boom provides digging depths down to 6′ to 8′; cutting widths are from 17″ to 24″. Being exceptionally compact, the 406 works in close quarters as well as in the wide open spaces.

Vickers Hydraulics has an important part in the performance of the 406. The boom hoist is driven by a Vickers Hydraulic Motor which provides positive control at all times . . . boom cannot float or sink in ditch. Raising or lowering of boom is easily accomplished. Another Vickers Hydraulic Motor quickly shifts the conveyor from the extreme position on one side of machine to the other (or any intermediate position). When working under close or irregular conditions, this feature is invaluable in gaining clearance. The Vickers Pump shown also supplies power for the hydraulic brakes.

Vickers Hydraulics improves the operation of a great variety of construction machinery. Get in touch with the nearest office for information and data on Vickers hydraulic equipment designed and built expressly for construction machinery and information on other cost-cutting applications.

Vickers Double Pump consists of two vane type pumps driven from same shaft . . . providing power for two separate hydraulic circuits. Exclusive "hydraulic balance" construction assures longer pump life.

Vickers Sectional Type Multiple-Unit Valve is available in many combinations for convenient and selective control. Includes relief valve for overload protection.

Vickers Gear Type Hydraulic Motor has complete hydraulic balance (both radial and axial) that eliminates pressure loads, thus providing longer life, higher operating efficiency, greater practical operating pressure.

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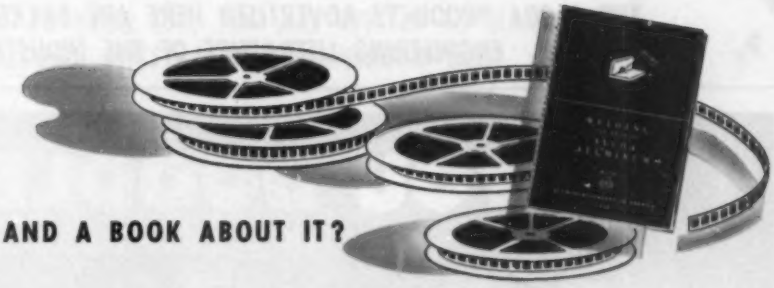
Why



FOUR MOVIES AND A BOOK ABOUT IT?

Aluminum can be joined by every possible fusion process—something no other metal can claim. Yet a few years ago not many production men knew aluminum could be welded at all. What happened to spread all this know-how?

Most of the credit goes to four Alcoa sound movies . . . Torch Welding, Arc Welding, Resistance Welding and Brazing Aluminum. Four movies and a comprehensive book describing all four processes. We seeded the industry with this basic literature. Now when a designer or a production man wants to join aluminum he not only knows he can weld it—he knows from *free* Alcoa literature, the best process to use and the right way to go about it.

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The key to Alcoa's technical library is a little folder which describes every piece of literature. You can get a copy from your local Alcoa sales office, or by writing: ALUMINUM COMPANY OF AMERICA, Gulf Building, Pittsburgh 19, Penna.

IN ADDITION TO FLAT AND COILED SHEET • ALCOA MAKES INGOT • BAR • ROLLED AND EXTRUDED SHAPES • WIRE • ROD • TUBING • PIPE • SAND, DIE AND PERMANENT-MOLD CASTINGS • FORGINGS • IMPACT EXTRUSIONS • ELECTRICAL CONDUCTOR • SCREW MACHINE PRODUCTS • FASTENERS • FOIL FABRICATED PRODUCTS • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

ALCOA

ALCOA

FIRST IN ALUMINUM

In the following pages, Alcoa presents facts for sales designers on representative Alcoa products. On the last page of the Alcoa section will be found the Alcoa offices through which information on aluminum is available.

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THE ALCOA PRODUCTS ADVERTISED HERE ARE BACKED BY THE BASIC ENGINEERING LITERATURE OF THE INDUSTRY...

IN ADAPTING THEM TO YOUR USE, YOU ARE INVITED TO MAKE FULL USE OF ALCOA'S OUTSTANDING ENGINEERING HELP

WE'LL DO IT

We'll squeeze Alcoa Aluminum into your design

When your design calls for a metal shape with an odd or expensive-looking cross section, chances are we can squeeze it out for you as an Alcoa Aluminum Extruded Shape.

This remarkable metal-working process reproduces your design and spares you many of the design compromises required when parts are to be built up by welding or riveting.

Let's get our heads together. Alcoa will work with you from the drawing board stage to the finished extruded shape.

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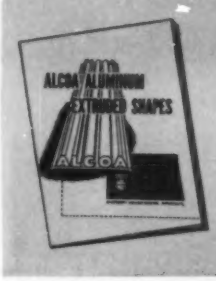
The use of Alcoa Aluminum Extruded Shapes frequently works major savings—by reducing the number of parts you need, by eliminating machining, and by cutting assembly operations. Often dies pay for themselves on the first thousand pieces.

And help you make a better product

The strength of Alcoa Aluminum alloys, their light weight and corrosion resistance may make an important contribution to your product. So may the clean-lined sections which extrusion produces.

The accumulated research and production experience of Alcoa is available to tailor these properties to your particular needs.



DESIGN PROBLEM?

"ALCOA ALUMINUM EXTRUDED SHAPES" is an informative booklet which shows you the design potentials of this endlessly versatile process.

Fill out the coupon at right. We will send you the booklet plus a paperweight made as an Alcoa Aluminum Extruded Shape.

Send for this free booklet today!

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ALCOA ALUMINUM SAVES ON SCREW MACHINE PARTS

Take a few extra minutes to figure your next screw machine job in *both* Alcoa Aluminum and brass. The big saving is possible because you get as many parts from 1 pound of aluminum as you get out of 3 pounds of brass.

Machining aluminum frequently costs less. And you eliminate finishing altogether because it resists corrosion. But if painting or plating are desired, remember that aluminum takes any finish other metals take.

The free book, "Alcoa Aluminum in Automatic Screw Machines", contains complete information on designing and machining. Write ALUMINUM COMPANY OF AMERICA, 2117E Gulf Building, Pittsburgh 19, Pa.

ALCOA Aluminum SCREW MACHINE STOCK

ALCOA ALUMINUM

THE ALCOA PRODUCTS ADVERTISED ON THESE PAGES ARE BACKED BY ALCOA'S RIGID QUALITY CONTROL...

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AT 40% LESS THAN PREWAR PRICES!

Have you figured aluminum forgings lately? Alcoa has brought quantity prices down with new production techniques, improved facilities. Now you can stay within cost limits . . . and still give your product the benefit of these competitive design advantages:

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- Tough, finely-knit grain structure
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Here's the answer to many a difficult design problem. Maybe yours. It's easy to find out. Our forging specialists are ready to work with you. Just mail the coupon below, or call your nearby Alcoa Sales Office.

ALCOA

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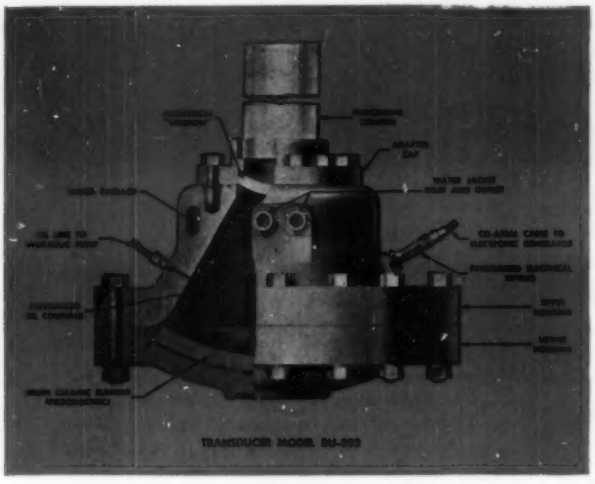
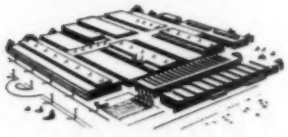


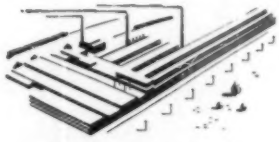
Cutaway view of the Hypersonic Transducer manufactured by The Brush Development Company which finds industry-wide application for emulsification, vaporization, homogenization and degassing of various liquids and solids.

CLEVELAND, OHIO



Sand & Permanent Mold Foundries

DETROIT, MICHIGAN



Permanent Mold Foundry

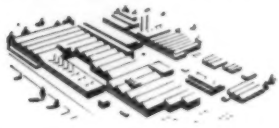
Typical of the tough ones cast by ALCOA

Would you torture your product with a test like this? Brush Development tests the castings we make for their Hypersonic Transducer by filling them with oil under 1,000 pounds pressure—then gives them the quivers at 125,000 vibrations per second. Yet not a trace of oil seeps through.

Whether you're after pressure tightness—or faster machining—or lighter weight—or lower finishing costs—specify Alcoa Castings. The larger the run—the tougher the job—the more Alcoa's modern foundries can save you. No others match our 62 years of aluminum experience. Few equal our production facilities.

Look for Aluminum Company of America listed in your phone book under "Aluminum". Call there for a casting specialist, or write ALUMINUM COMPANY OF AMERICA, 1999E Gulf Building, Pittsburgh 19, Penna.

BRIDGEPORT, CONN.



Sand & Permanent Mold Foundries

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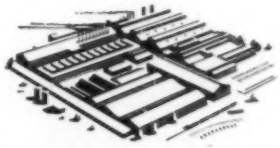

Sand & Permanent Mold Foundries

ALUMINUM CASTINGS by ALCOA

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These sources of the Alcoa products (described on the preceding pages) are as near as your telephone. Let them serve you with engineering help, literature, and a pound or a ton of the Alcoa product that best meets your needs.

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Phone Tucker 5121
San Francisco—615 Russ Bldg.
Phone Yukon 6-6484

COLORADO
Denver—524 U. S. National Bank Bldg.
Phone Tabor 4638

CONNECTICUT
Fairfield—1333 Post Road
Phone Fairfield 9-5221
Hartford—Capitol Bldg., 410 Asylum St.
Phone Hartford 5-2192 to 5-2196

DELAWARE
Wilmington—Delaware Trust Bldg.
Phone Wilmington 8-4138 and 8-4139

FLORIDA
Tampa—1004 Tampa Theatre Bldg.
Phone 2-1984
Miami—1129 Alfred I. Du Pont Bldg.
Phone Miami 9-0651

GEORGIA
Atlanta—1800 Rhodes-Haverty Bldg.
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Peoria—415 Commercial Natl. Bank Bldg.
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INDIANA
Fort Wayne—1935 Lincoln Tower
Phone Eastbrook 4676
Indianapolis—817 Merchants Bank Bldg.
Phone Market 2501
South Bend—805 J. M. S. Bldg.
Phone 2-3333

IOWA
Davenport—503 Kahl Bldg.
Phone 2-6243 and 2-6244

KANSAS
Wichita—411 Fourth Natl. Bank Bldg.
Phone 5-6624

KENTUCKY
Louisville—1154 Starks Bldg.
Phone Wabash 7456 and 7457

LOUISIANA
New Orleans—627 Whitney Bank Bldg.
Phone Canal 3372

MARYLAND
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Phone Saratoga 8091 to 8094

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Phone Hancock 6-2638, 6-2639, 6-2640, 6-2641, and 6-2694
Springfield—507 Tarbell—Watters Bldg.
Phone Springfield 3-5103

MICHIGAN
Detroit—610 New Center Bldg.
Phone Trinity 1-8100
Grand Rapids—812 Michigan Natl. Bank Bldg., Phone Grand Rapids 9-0209
Jackson—1203 National Bank Bldg.
Phone Jackson 2-8206
Pontiac—301 Pontiac State Bank Bldg.
Phone Pontiac 4-1531

MINNESOTA
Minneapolis—1060 Northwestern Bank Bldg., Phone Atlantic 3528

MISSOURI
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Phone Victor 3870
St. Louis—10th Floor, Continental Bldg.
Phone Franklin 6700

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Phone Market 2-6664

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Phone Murray Hill 6-8046 to 6-8058
Rochester—1331 Lincoln Alliance Bank Bldg., Phone Baker 2630
Syracuse—408 State Tower Bldg.
Phone 3-0156

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Cincinnati—801 Enquirer Bldg.
Phone Parkway 7700
Cleveland—1450 Terminal Tower
Phone Cherry 6880
Columbus—40 South Third Street Bldg.
Phone Adams 5251
Dayton—302 Harries Bldg.
Phone Hemlock 1112
Toledo—1801 Ohio Bldg.
Phone Main 6295

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Portland—510 The U. S. Natl. Bank Bldg.
Phone Atwater 6605

NORTH CAROLINA
Charlotte—616 Johnston Bldg.
Phone 4-9751

PENNSYLVANIA
Allentown—913 Hamilton Street
Phone Allentown 3-7463 and 3-7464
Philadelphia—123 S. Broad Street
Phone Kingsley 5-0250 to 5-0257
Pittsburgh—2012 Oliver Bldg.
Phone Atlantic 1-4545
York—205 Manufacturers Bldg.
Phone York 2044 and 7441

RHODE ISLAND
Providence—815 Industrial Trust Bldg.
Phone Jackson 1-4108 and 1-4109

TEXAS
Dallas—301 Thomas Bldg.
Phone Riverside 6292
Houston—1806 Commerce Bldg.
Phone Preston 7106

VIRGINIA
Richmond—213 Exchange Bldg.
Phone Richmond 3-8393 and 3-8394

WASHINGTON
Seattle—1411 Fourth Ave. Bldg.
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Milwaukee—735 N. Water Street
Phone Marquette 8-0185

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FORMABILITY!

ZINC DIE CASTINGS ARE EASILY SPUN OR OTHERWISE FORMED AFTER CASTING

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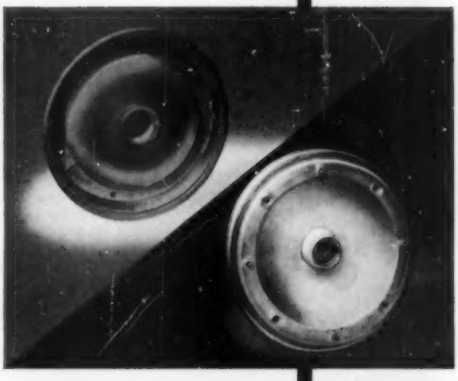
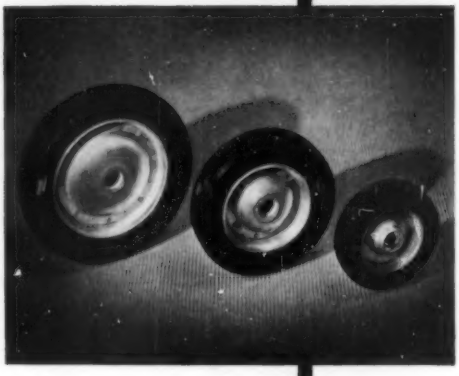
Thanks to the ductility of ZINC die castings, the two identical castings at the right are assembled easily to form a complete hub for a new type lawn mower wheel. Each casting has four integral studs and four holes. Assembly is completed by merely inserting the projecting studs on each casting through the holes on the other, and spinning the counter-sunk stud ends with an ordinary spinning tool. Abuse tests have proved that the spun stud type of construction provides an indestructible bond between the mating castings.



FOR WHEELS OF UNUSUAL STRENGTH

The above means of assembly was employed for each of the three sizes of rubber tired wheels pictured here. Although the average wall thickness of the die cast hub halves is only .05", the J. G. Doyle Engineering Company has produced wheels of unusual strength. Designed primarily for use on lawn mowers, the sturdy construction achieved — at low cost — by the use of ZINC die castings, should make these wheels applicable for such other heavy duty applications as wheelbarrows, dollies, etc.



The ability to perform spinning, heading, swaging, bending and forming operations on ZINC die castings is only part of the story of why ZINC is the most widely used die casting metal. Every die casting company is equipped to make ZINC die castings and will be glad to discuss their advantages with you. Or write to us.

ZINC
FOR DIE CASTING ALLOYS

The New Jersey Zinc Company, 160 Front Street, New York 7, New York.

The Research was done, the Alloys were developed, and most Die Castings are based on

HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

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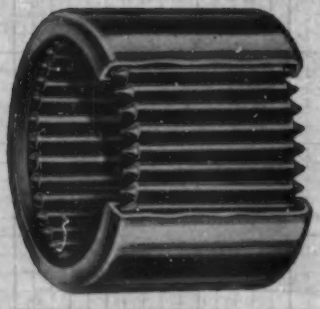
give maximum load distribution

Torrington Needle Bearings distribute radial loads over a greater bearing area than any other type of anti-friction bearing of comparable size.

This unique engineering feature of Torrington Needle Bearings assures maximum load capacity for any given housing or shaft size.

Where you encounter high load conditions with fixed or rigid space limitations, you will find the Torrington Needle Bearing specially engineered to give you this and other important advantages. Why not discuss your problem with our engineers? They'll be glad to help you.



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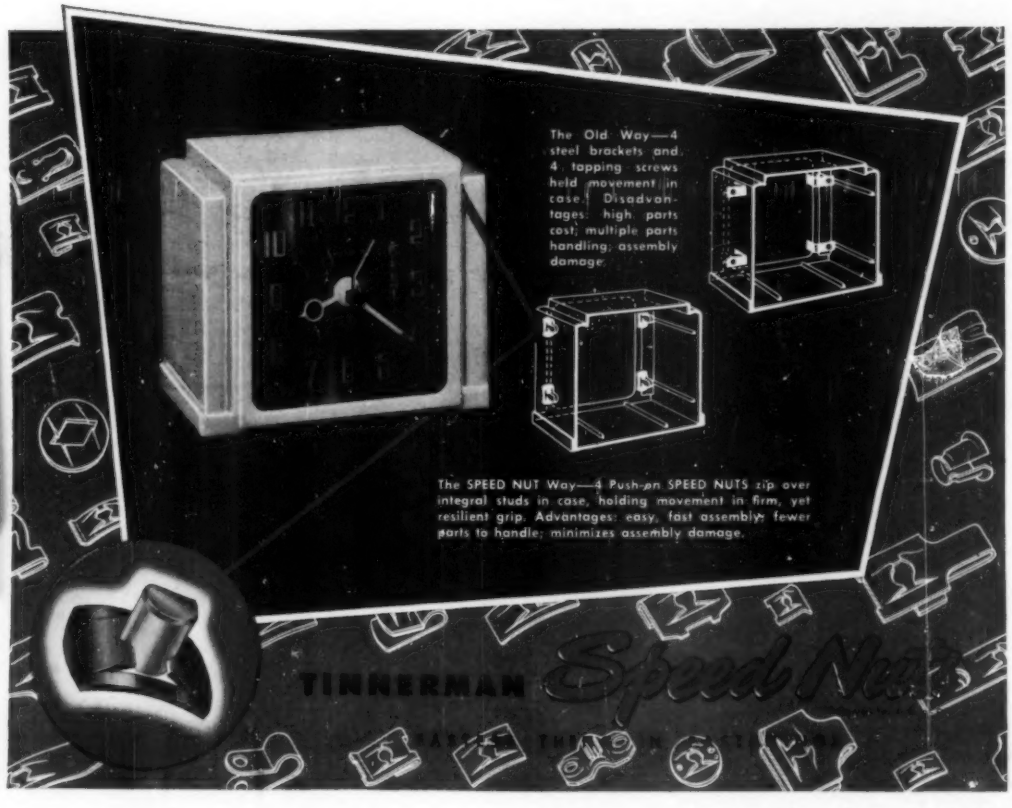
by TINNERMAN "TIME-SAVERS"

It was a profitable decision when The Sessions Clock Company selected SPEED NUTS for an important job in the assembly of their famous "Melody" alarm clocks.

By providing a simpler, faster method of attaching the movement to the plastic case, Push-on type SPEED NUTS are saving thousands of dollars annually. This savings was reflected in lower parts cost, shorter assembly schedules, and fewer rejects.

Clocks, cars, or cap-pistols . . . whatever you manufacture, you'll find that SPEED NUT brand fasteners can provide faster, more economical ways to assemble your products. May we conduct a convincir Fastening Analysis for you? Contact your Tinnerman representative for details. And write for your copy of "Savings Stories". TINNERMAN PRODUCTS, INC., Cleveland 13, Ohio. In Canada: Dominion Fasteners Limited, Hamilton. In England: Simmonds Aerocessories, Ltd., Treforest, Wales.


The Old Way—4 steel brackets and 4 tapping screws held movement in case. Disadvantages: high parts cost; multiple parts handling; assembly damage.
The SPEED NUT Way—4 Push-on SPEED NUTS zip over integral studs in case, holding movement in firm, yet resilient grip. Advantages: easy, fast assembly; fewer parts to handle; minimizes assembly damage.
TINNERMAN
Speed Nut

Competitive Enterprise And the Product Engineer

IN COMMERCIAL TRANSACTIONS costs are expressed in monetary units that fluctuate widely and rapidly in value. Tariffs, taxes, political situations, inflation and many other things tend to becloud the fact that material progress stems only from producing more with less labor and developing new products for better living.

Comforts, luxuries and the physical welfare of man can increase only in the inverse ratio of the hours of labor required to produce the goods and services he wishes to enjoy. Part of the cost of the product is in the building, machinery and equipment required for the manufacturing operations. Some is in the materials and components purchased to build the product. The balance is the labor and supervision expended in making the product.

The capacity and efficiency of the production machinery used is the greatest single factor determining costs. This applies not only to shop manufacturing operations, but practically to all other industries as well—construction, mining, transportation, farming and others. The effects of greater production with fewer hours of labor are obvious.

Only by producing more with less labor can man improve his material well being. That is the only way he can do it. And to do it, he must have at his disposal the most modern and efficient production equipment. The development of this equipment, as well as the products that it produces, are the responsibility of the design engineer. Thus it is that the design engineers' accomplishments determine the course of nations and humanity and make available more and better products to enjoy and the leisure in which to enjoy them.

Of course it is not solely the design engineer who does it all. He must have at his disposal certain of the resources and the backing of an organization, usually his employer. This organization or employer must be permitted to operate in an atmosphere conducive to pioneering and enterprise. There must be lively competition to goad the employer to taking the risks. And those who furnish the risk capital must be permitted to retain a reasonable portion of the profits, if there be any, to enable them to underwrite subsequent ventures.

Only so long as we have competitive enterprise and a successful manufacturer can retain a reasonable share of its profits, can design engineers continue to improve products, create new ones, and make possible the production of more with less labor—and thereby reduce the cost of finished products.

G. F. Zodenholt

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MONEY SAVERS

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I ADAPT MYSELF TO ANY SHAFT
MY OIL-CIRCULATING SYSTEM IS BUILT IN
I PUMP AND CIRCULATE THE OIL I NEED
I FILTER AND STORE THE OIL I NEED
I REDUCE "FLASH" FIRES IN TREADLE ROLLS
MY OIL IS RENEWED BY "HYPO" INJECTION

THIS MONTH at Atlantic City the great and growing textile industry stages its National Show, to present the latest and best in processes and equipment.

Illustrated here are six ball bearings, typical of the many originated and developed by New Department. They will be on display at the New Departure exhibit where visiting designers and engineers customarily spend much of their time.

And no wonder! For most of the advances in ball bearing design for textile machinery these last ten years came from New Departure. Engineering literature, descriptive of them, will be mailed promptly to requests on business letterheads.

Nothing Rolls Like a Ball... **NEW DEPARTURE BALL BEARINGS** 93

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

He's top man in his department, but—how does he stand in the corporate organization?

The Chief Engineer

His Status and Responsibilities

A survey of Chief Engineers in basic industries shows wide differences in duties, responsibilities, and company standing. The main question is: To be or not to be, an officer of the company? Whether 'tis better to suffer the slings and arrows of outrageous fortune or to try for that V.P. position?

ARTHUR LAZARUS
Vice President, Day & Zimmerman, Inc.

OFFICE BOYS are supposed to wind up as presidents, salesmen fully expect to be vice-presidents, and even the president's nitwitted brother-in-law gets on the Board of Directors. How about the engineer? If he gets to be chief engineer, then chief engineer he stays—in the majority of cases. If all the Toms and Dicks and most of the Harrys can eventually get to be officers in a firm, why is the chief engineer left out? This state of affairs forces many young engineers into sales or management jobs, and deprives the engineering profession of some of its best talent.

In an effort to find out the exact status of chief engineers today in a variety of industries, the following letter was sent out to over 100 chief engineers:

"We do not believe the post of chief engineer is generally accorded the importance it merits. Whereas, the head of the manufacturing department and the heads of the sales and financial departments are usually vice presidents and members of the Board of Direc-

tors, this is infrequently the case with the chief engineer. Yet it is felt that the chief engineer performs just as important a function in a company as do the other executives."

"We should appreciate your cooperation in developing a more comprehensive understanding of the position of the chief engineer. Would you tell us: (1) To whom do you report? (2) Are you given the status of an officer of your company? (3) What are your duties?"

The entire results, gathered from the 79 replies obtained can be seen in the accompanying table.

Divergent Opinions Expressed

Even more interesting than the compiled results are the comments and ideas expressed in these replies. Among the overwhelming majority of those who are neither officers nor directors, the replies fell roughly into these divisions:

1. Those who wanted to be a vice-president and were somewhat bitter because they weren't.

2. Those who wouldn't touch a vice-president's position with a 10-foot pole.

Now here are some chief engineers who are perfectly happy to keep the position which they feel to be respected and respectable:

"With all due respect to vice-presidents, why," asked one chief engineer, "should a chief engineer want to be one of a number of vice-presidents, which is so often the case in larger companies, when you can be the only chief engineer in the company?"

An equivalent view is expressed by a chief engineer of one of the larger oil companies:

"I have not equal authority with most of our vice-presidents, but more than some. As a vice-president, I would have equal status with others; then in a company that may have from five to 40 vice-presidents, there is some advantage in being the only chief engineer."

Another chief engineer believes his company would derive no benefit from making the chief engineer an officer. He feels he is strongly supported by the management, and can think of nothing which might improve this relationship. The title, "vice-president" would be almost unbearable to a third chief engineer.

Another group believes the chief engineer gets about what he deserves. When broader-minded, better educated, more capable chief engineers are produced, the post will be accorded the importance it merits, in this view:

"In my opinion," one chief engineer writes, "whether you call a man a chief engineer or not, if an individual has any 'stuff on the ball' you will find the position he is filling is generally accorded the respect it deserves."

A vice-president of engineering injects a new note as follows:

"Offhand, I would say that the status of chief engineer is very likely determined by his engineering and sales ability."

Another chief engineer has the importance extended to the chief engineer as determined by his capacity, and to a larger extent, by the nature of the organization with which he is associated. This thought has been succinctly expressed by an outstanding engineer in this wise:

"I have several times considered this matter, and without being able to speak authoritatively have reached the conclusion that the engineer in the industry pretty much occupies the position he deserves, based upon the importance of his contribution. In industries where his performance is vital, he seems to have retained a relative ranking corresponding to his actual place in the picture."

Some Feel Slighted

On the other hand, great numbers of chief engineers feel that they suffer real inequalities in their non-official positions. They say:

"Aside from not having this status of an officer of the corporation, I attend management meetings and other small confidential sessions with directors. Unlike an officer, I receive a straight salary only, without their 'earning clause' which more than doubles their salaries."

"This discrimination," one engineer says, "also reflects itself in rates of pay,—in that sales, or even manufacturing, are usually much more highly paid than men of engineering in comparable responsibilities or greater."

Another engineer states: "I can speak with feeling on the subject. As chief engineer for five years for a large company, I reported to the vice-president in charge of sales and was not an officer of the company. During the past 20 years in my present company, I have reported to the works manager, who was at first vice-president, and for the past 12 years president of this company. About eight or nine years ago I was made an officer of the company, not as an engineer, but with the title of assistant treasurer, only for the purpose of being one of several who is authorized to countersign checks and other such papers."

This same sentiment is expressed by still another man who states, "This undoubtedly is due to the fact that there is a general feeling on the part of the average executive and run-of-the-mine vice-president, that engineers, including chief engineers, are sort of necessary evils of an annoying character."

Some chief engineers feel that inadequate rating given to the profession may have serious connotations. They see a draining off of engineering talent to sales work, rather than to the improvement of engineering. The following quotation sets forth this viewpoint:

"While it is true that I sit on committees of which the majority of the members are vice-presidents and other officers, and have an equal voice in the deliberations of the committee, yet the fact remains that the chief engineer in most companies is not given the status of an officer. I strongly feel that if the engineering profession were given a little more recognition in this and in other respects, we would not be experiencing the condition we have today, when 90 percent to 95 percent of the engineering graduates go into sales work, rather than into an engineering department where their education will certainly do the country most good."

One chief engineer feels that his lack of official status has a hampering effect in his dealings and encounters with company officials. He says: "I wish to point out that this is not pure vanity in my individual case. I feel with the status of vice-president a better coordination of effort and much cutting of red tape could be effected. There is one point which I wish to cover: That is, in regular get-togethers with top executives for meetings to discuss major issues, it is difficult if not impossible to handle meetings of this kind, which I think are of extreme importance, unless the people attending the meetings are of an approximately equal status."

One engineer believes the comparative inferior position of the chief engineer is due to the engineer's overcaution and in articulateness. He says: "All too frequently the professional engineer takes refuge behind the slide rule, and with laudable caution hesitates to express himself on matters unproved to him."

The net result has been that those more glib and less exacting men who look at wider horizons end up in top administrative posts. Are not the engineers themselves to blame in a large measure by their deliberate high intensity consideration of a small field of operation?"

These foregoing opinions are not universally held. One chief engineer believes his fellow chief engineers are paid more generously, and have greater

The Position of the Chief Engineer on Selected Industries

	Air-craft	Auto-motive	Build-ing Prod-ucts	Chemi-cal	Foods	Iron and Steel	Mach-ine Parts	Miscel-laneous Indus-tries	Oil Com-panies	Rubber Manu-fac-turers	Tex-tiles	Total
Number Polled	4	9	6	9	11	11	11	8	3	3	4	79
Officer of Company												
Yes	3	6	—	1	1	4	8	2	2	—	—	27
No	1	3	6	8	10	7	3	6	1	3	4	52
Director of Company	—	2	—	—	—	—	2	2	—	—	—	6
Member of Executive Committee	—	1	—	—	—	—	—	1	—	—	—	2
Chairman of Board		1										1
Executive Committee				1								1
President	2	5		1	2	3	8	6	1		3	31
Executive Vice-President				1		2	1					4
Vice-President, General Manager					1							3
Vice-President Production			4	4	3	3	2	2	2	3		23
General Manager				1	1							2
Manager of Production					1							1
Plant Manager					1						1	2
General Superintendent					1	2						3
Director Engineering and Research			1									1
Director Engineering Vice-President, Engineering and Sales	2											2
Vice-President, Engineering		1			1	1						3

flexibility than most vice-presidents, to wit:

"On the other side of the argument, however, we do want to point out to you that we believe in many cases the chief engineer is paid more money than the average vice-president, because he is not so easily replaced; secondly, because he usually and generally has more education than the vice-president; also, because the average vice-president cannot leave and be a vice-president somewhere else, but practically any chief engineer who has the experience and reputation for doing things, can go out and get a job as good as any he is holding, and if he cares to, can probably open a consulting office and do even better from a financial standpoint."

Job Titles Are Confusing

If this survey shows anything, it shows that the title Chief Engineer is absolutely no measure of the position or duties of an individual. Probably the main reason why there is no standard position for chief engineer is because it is no standard job. There is much disagreement among engineers themselves as to just what the job is. To quote from one of these letters: "I share your experience that a considerable heterogeneity exists with respect to the duties of the chief engineer. The difficulty, I think, will always be with us, as long as the term: 'engineer', is used to describe a man who gets more heat in the apartment, and the man who designs the B-29".

And this opinion is borne out by many of the others who answered the questionnaire.

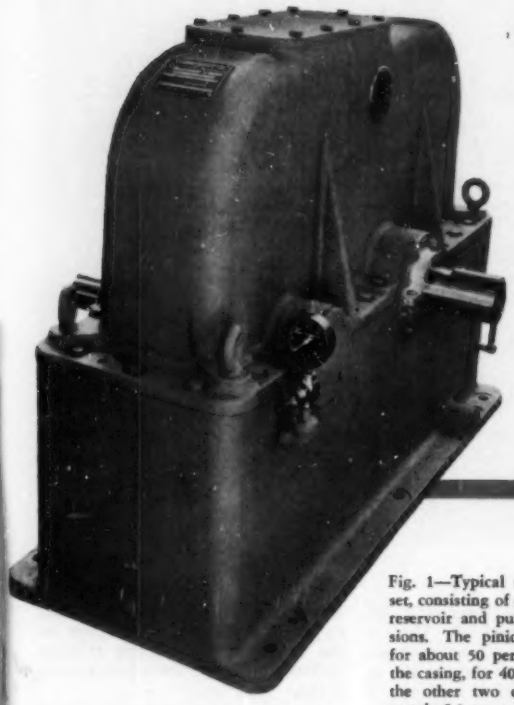
Taking chief engineers by the industries that they serve, it is quickly seen that there is a wide difference in the main responsibilities of the jobs. For example, the survey shows that chief engineers in the automotive or machine parts industries divide their time between product design and development, and administrative duties. They are not too concerned with manufacturing methods or maintenance. On the other hand, in the food, chemical, and building products industries chief engineers spend most of their time on the design and construction of plant facilities, and have few administrative duties.

The industries which place a strong administrative demand on the chief engineer also reward him with a higher official position. Whether or not this trend towards administrative duties for the engineers is healthy, is open to debate—surely, many chief engineers find that an excess of these duties tends to overshadow their main function as an engineer. The status and responsibilities of the chief engineer in industry are not fixed, but are rather in a state of development. It is possible to note increasing recognition of his work. This trend is particularly discernible in the iron and steel industry. Further clarification and understanding of the chief engineer's responsibilities and services are badly needed.

It is hoped that the present study, made possible by the cooperation of numerous representatives and chief engineers, will contribute to that end.

Estimating the Weight

Of Single Reduction Gear Sets



How pinion speed, horsepower transmission capacity, tooth contact pressure and speed ratio affect the weight of single-reduction gear sets. Charts, tables, and general relationships that will facilitate estimate without tedious analyses.

D. W. DUDLEY
Gear Engineering Division, General Electric Company

Fig. 1—Typical single-reduction gear set, consisting of a pinion and gear, oil reservoir and pump, and shaft extensions. The pinion and gear account for about 50 per cent of the weight; the casing, for 40 percent; and each of the other two components, approximately 5.0 percent.

THE SIZE AND WEIGHT OF GEAR SETS frequently are detriments that prevent or make difficult the accommodation of a drive in a machine or piece of equipment. In many instances the designer may seriously debate whether to use a gear set or whether to specify a direct drive, even though in the latter instance the driving apparatus must operate at a speed that is inefficient for best performance. Therefore, it is helpful to have some guide for estimating the approximate weight of a gear set.

The primary factors that determine the size of reduction gearing are horsepower capacity, pinion speed and gear ratio. These three items comprise the power rating. To find a basis for estimating weights, it is necessary to combine these items into a single factor that expresses quantitatively the size of the job that the gear set must handle. This factor then becomes a yardstick that can be used to determine the approximate weight of the gear.

From the weight standpoint, the size of a single-reduction gear appears to be best evaluated by the Q factor:

$$Q = \frac{\text{Horsepower}}{\text{Pinion rpm}} \times \frac{(m_G + 1)^2}{m_G} \qquad (1)$$

where m_G=gear ratio=Pinion speed/Gear speed.

It is obvious from this equation that the Q factor depends considerably on the amount of power used to drive the gear. The source of power and the nature of the load to which the gear is connected must also be evaluated. Frequently the horsepower figure used in computing the gear size is larger than the actual horsepower. Standard practice is to consider that a gear set has a unity service factor when an electric motor drive is used and the duty cycle is 8 to 10 hr per day, with not more than 100 percent overload at starting or more than 100 percent momentary overload during operation. For other conditions of operation a "service horsepower" is calculated as follows:

Service hp = Actual hp x Service factor

This service horsepower, rather than the actual horsepower, should be used to calculate Q-factor. Table I gives the service factors approved by AGMA for conventional gear applications with the exception of high speed gears.

Basis of the Q-Factor—Weight Relationship

To actually check the Q-factor—weight relationship, Q-factors were calculated for the nearest ratios to 2, 6, and 10, using published data from different manufacturers of single reduc-

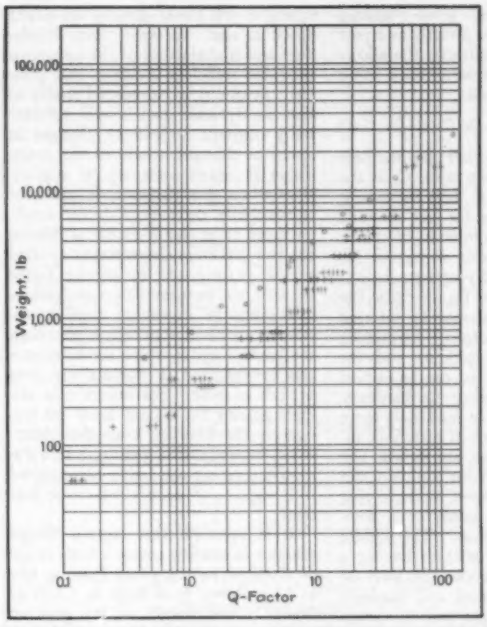


Fig. 2—Mass plot of data from published information of gear manufacturers showing the Q-factor and weight relationship. Circles are for high speed gears, and crosses, for low speed gears.

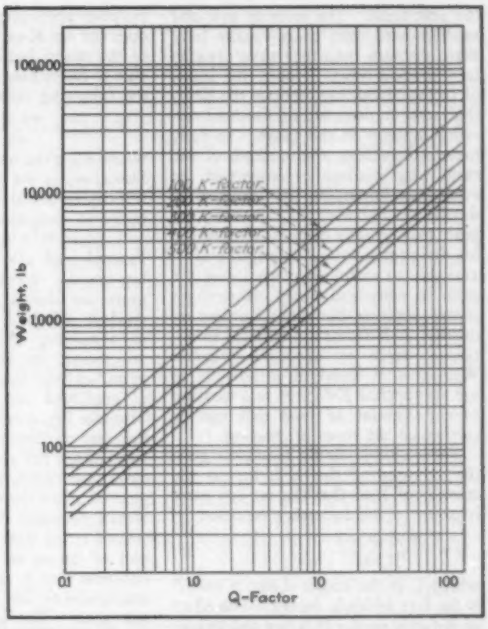


Fig. 3—Effect of tooth loading intensity on weight for full weight design. It is apparent that weight can be substantially reduced by designing the gear to carry heavier tooth loads.

tion gear sets such as shown in Fig. 1. In this case, the gear set is a complete and independent piece of machinery. The unit comprises a pinion and gear, a complete gear casing, an oil reservoir and oil pump, and shaft extensions. The foundation for the gear is separate. Results of this mass plot of data are shown in Fig. 2. The circles are for high speed sets, and the crosses, for low speed sets. (In AGMA Standard 421.02, a high speed gear is defined as one in which the pinion has a speed of 3,600 rpm or higher or a pitch line velocity of 4,000 fpm or higher.)

Although there is a considerable spread in Fig. 2 between the heaviest and lightest units, the data shows a definite correlation between weight and Q-factor. There is certain to be some variation due to one designer being more conservative than another and due also to differences in manufacturing methods.

The logical basis for this relationship lies in the fact that when single reduction spur gears are designed for a constant Hertz contact pressure, the Q-factor is proportional to the face width multiplied by the square of the center to center distance. Therefore, in estimating gear weights, it is important to determine in advance the approximate intensity of tooth loading that can be successfully carried on the type of gear in question. There are several different formulas used to calculate the strength of gear teeth, the wear capacity of gear teeth, and the ability of gear teeth to resist scoring, abrasion, overheating, and other conditions encountered in service. For general purposes, though, the K-factor serves as the best index of tooth loading. This factor is defined in AGMA Standard 421.02 as follows:

$$K = \frac{W}{D_P} \times \frac{m_a + 1}{m_a} \qquad (2)$$

where W is the tooth load in lbs per in. of face, D_P is the pitch diameter of pinion in inches, and m_a is the ratio of the number of teeth in the gear to the number of teeth in the pinion. Strictly speaking, the K-factor is only a measure of the surface durability of

Table I—Service Factors for Gear Sets Under Different Operating Conditions

Character of Load on Driven Machine	Electric Motor Drive			Multi-Cylinder Gas Eng. Steam Eng. or Turbine			Single-Cylinder Gas Engine		
	Intermittent 3 hr per day	8–10 hr per day	24 hr per day	Intermittent 3 hr per day	8–10 hr per day	24 hr per day	Intermittent 3 hr per day	8–10 hr per day	24 hr per day
Uniform	0.8	1.0	1.25	1.0	1.25	1.5	1.25	1.5	1.75
Moderate Shock	1.0	1.25	1.5	1.25	1.5	1.75	1.5	1.75	2.0
Heavy Shock	1.5	1.75	2.0	1.75	2.0	2.25	2.0	2.25	2.5

the gear teeth. The teeth of soft and medium-hard steel gears usually have more strength than they have capacity to withstand wear. Hence, the index of surface durability becomes the limiting factor in determining the load carrying capacity of the gears. In fully hardened gearing, the strength of the teeth may become as important, or even more important, than the surface durability, but even in this case, the gear designer can often so proportion his design that enough strength will be available to match the capacity of the teeth to withstand wear. If strength is more limiting than wear, a proper reduction in K-factor can still aid in obtaining teeth of adequate strength. With this in mind, it is possible to use appropriate K-factors as a measure of the amount of load that can be carried on all types of gearing.

For a simple single reduction gear, the relation of the K-factor to the amount of load that the set can carry is given by the following equation:

$$Q = \frac{K \times C^2 \times F}{31{,}500} \qquad (3)$$

where C is the center distance and F is the face width in inches. The effect of K-factor on the Q-factor and weight relationship can be seen in Fig. 3, which was prepared from Fig. 2. These curves clearly show that one method of obtaining lighter gear sets is simply to design and build gears capable of carrying higher K-factors.

Allowable K-Factors for Different Applications

Since the K-factor is of such importance in determining gear weights, it is desirable to be acquainted with the load rating practice for different types of gears so that weights may be based on allowable K-factors.

Standard 211.01 of the AGMA covers the surface durability rating of helical gears used in low-speed general purpose applications. This standard does not use K-factor directly as a part of the rating, but indirectly the allowable K-factor may be determined using the following formula:

$$K = K_r \times \frac{m_a + 1}{m_a} \times C_v \times \frac{F_i}{F} \qquad (4)$$

where K_r is the materials and hardness factor, m_a is the gear ratio, C_v is the velocity factor, and F_i/F is the inbuilt factor to compensate for size of parts and possible misalignment of parts. Examples of allowable K-factors for low-speed, general-purpose helical gears are shown in Fig. 4. In the AGMA standard previously referred to, a number of different hardnesses are shown for the pinions and the gears, and the load that can be carried is graduated according to hardness. To make Fig. 4 easy to read, only three different combinations of materials, instead of the full range, are shown. The two lower curves are for a pinion and gear of about the lowest hardness that would normally be used for a heat-treated set of steel gears. The middle pair of curves are for teeth having a hardness that is at about the limit of machinability for small and medium size gears. The upper pair of curves are for teeth having hardness that is ordinarily obtained by case-hardening and grinding.

It will be noted that the allowable K-factor decreases as the face width increases. The reason for this lies in the fact that slight errors in gear teeth cause dynamic overloads when gears are run at high speed. The severity of the dynamic overloads increases as the speed increases, and also increases as the size and weight of the gearing increases. Since face width is a measure of size, and pitch line velocity is a measure of speed, it can be seen that the load rating of the gear can be expected to decrease as these factors increase.

In many gear applications, the load rating is not based directly on either speed or size. In these cases, the design and manufacture of the apparatus provides sufficient accuracy and sufficient flexibility of connected shafts so that the dynamic load is held substantially constant in spite of changes in speed or changes in size of the gears. Table II shows some typical applications where gear parts are designed for substantially constant K-factor loads. In these cases the K-factor is figured for the maximum horsepower applied to the gearing and no service factor is used to increase this horsepower. However, the maximum rated horsepower may be substantially higher than the horsepower at which the apparatus can be expected to operate for long periods of time. For instance, in aircraft gearing the takeoff loads are frequently the limiting loads that determine the size of the gearing. In automotive gearing the loads encountered in low gear will usually determine gear sizes.

It is apparent that current design practice in gearing covers a wide range of K-factor values, going from as low as 55 or lower to as high as 1,500 or higher. The weight of the gear set will depend considerably on the K-factor, so, where weight is important, it is desirable to use a high K-factor. It may not be practical, though, from manufacturing considerations or from a cost standpoint to design large gears in the high K-factor range. Equipment available at present for producing hardened and ground gears is limited to relatively small size gears—in most cases gears under 24 in. in diameter. The cost of making precision, fully hardened gears is much greater than that of producing gearing at low hardness which can be cut after heat treatment. Thus, in many applications, the gearing is designed for a K-factor that will permit the use of low-hardness gear parts, which are readily machinable.

Table II—Gears Designed for Constant K-Factor Loads

Application	K-Factor[1]	Pitch Line Speed	Minimum Hardness, Brinell
Turbine driving generator..	110	4,000 fpm or higher	Pinion—225 Gear—180
Internal combustion engine driving centrifugal compressor	63	4,000 fpm or higher	Pinion—225 Gear—180
Turbine driving pump or surge tank	55	4,000 fpm or higher	Pinion—225 Gear—180
Automotive helical transmission gears	1500	(low gear)	Case hardened to 58 R_C min. (587 Brinell)
Aircraft propeller drives, planetary	500	Usually less than 10,000 fpm	Case hardened to 58 R_C min. (587 Brinell)
Aircraft propeller drives, single reduction	1000	Usually less than 4,000 fpm.	Case hardened to 58 R_C min. (587 Brinell)

[1] Service factor included in K-Factor.

Other Factors Affecting Weight

There are, of course, other factors than tooth contact pressure that must be taken into consideration when estimating gear weight. The most important of these are: (1) number of parts of the gear set; (2) type of gearing involved; and (3) the materials and design techniques applied to the construction of the gear set.

MATERIALS AND DESIGN TECHNIQUES: It is possible to substantially reduce gear weights by using aluminum or magnesium for casing parts, and then making shafts hollow and gear webs thin so that a minimum amount of metal is used to support the gear teeth.

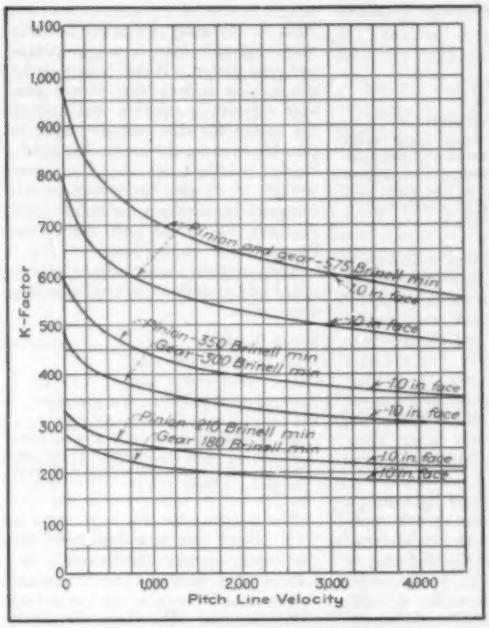

K-Factor
Pitch Line Velocity
Pinion and gear - 575 Brinell min
F = 1.0 in. face
F = 2.0 in. face
Pinion - 350 Brinell min
Gear - 300 Brinell min
F = 1.0 in. face
F = 1.0 in. face
Pinion 210 Brinell min
Gear 180 Brinell min
F = 1.0 in. face
F = 1.0 in. face

Fig. 4—Allowable K-factors for general-purpose low speed helical gears. Curves are based on AGMA standards 211.01. An entire family of curves can, of course, be obtained for various materials by plotting over a full range of hardnesses. Bottom curves are for low hardness machined gears; center, for high hardness machined gears; top, for case-hardened and ground gears.

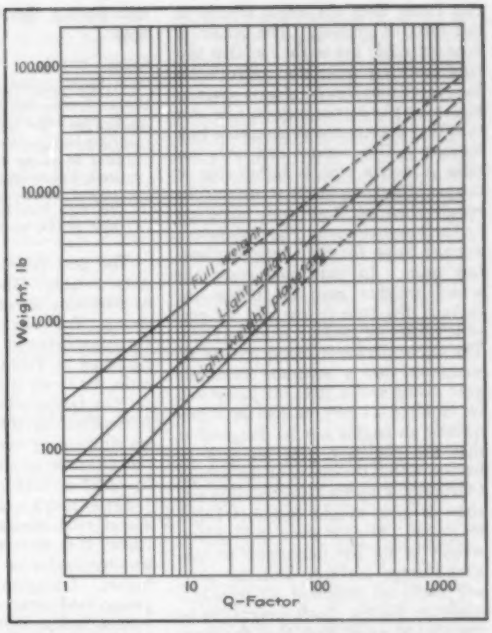


Fig. 5—How design and material effect the weight of gear sets. Upper curve is for conventional spur gearing and full weight construction; middle curve, for lightweight spur gearing with aluminum casing and other special design features; bottom curve, for light weight planetary gearing. Actual designs usually fall in region of middle curve. All curves are for 500 K-factor load.

This type of design is obviously expensive, but is justified in many aircraft applications when extremely light weight is required. A comparison between a conventional steel gear set operating at a 500 *K*-factor and a gear set having an aluminum casing and other special design features is shown in Fig. 5. The upper curve on Fig. 5 is the same curve as was drawn on Fig. 3 for 500 *K*-factor tooth loading; it represents a set of full weight construction, which is a practical design but one that is seldom made. The middle curve shows the average weight of light weight designs loaded to a 500 *K*-factor intensity. Since light weight designs and high tooth loading tend to go together, actual designs in most applications follow the region of the middle curve more than the upper curve.

The curves are all dashed at their upper ends because presently available manufacturing facilities in most cases make it impractical to fully harden the larger gears. The particular *Q*-factor at which the curves become dashed should not be interpreted too literally. The dashed part of the curve is intended only to indicate that it is difficult and in some cases impossible to build gearing in large sizes capable of carrying a 500 *K*-factor load.

COMPLETENESS OF THE GEAR SET: Obviously a complete gear set such as that shown in Fig. 1 will weigh much more than a partial gear unit which may sometimes be used. For instance, a cam shaft drive in a reciprocating engine may consist of only a pinion and gear. No casing is required because the gears are mounted within the casing of the engine. Lubrication and shafts on which to mount the gears are also available. In such cases as this and others involving only a part of a gear unit, the following figures may be used as a rough approximation of the division of weight in the unit:

Pinion and Gear	50 percent
Gear Shaft	5 percent
Casing	40 percent
Oil and Oil Pump	5 percent

TYPE OF GEARING: It is possible to considerably reduce the weight of gear sets by using planetary or other types of gears where the load is carried by more than one pinion. For instance, it is feasible to make a low-ratio planetary unit with as many as 10 planets. Since each of these planets would carry a share of the load and each would be quite light in weight, a considerable reduction in weight can be obtained if a set can be built with sufficient accuracy to guarantee that the load is properly shared. The difficulty in making all the planets share the load, however, may make it necessary to design these units for a lower *K*-factor than when a single pinion and gear is used. In aircraft gear work it has frequently been necessary to design planetary units for about ½ the intensity of loading on a single reduction gear set. But even though planetaries may not be able to carry as high *K*-factor as other types of gears, the greater number of pinions makes possible a substantial weight reduction. The *Q*-factor discussed previously can be used as a basis for comparing planetary gear weights with other gear weights, although it should be borne in mind that

this factor does not apply strictly to this class of gearing. The reason it does not apply lies in the fact that low ratio planetary units can conveniently have large numbers of planets whereas high ratio planetaries may only be able to have 3 planets due to geometric limitations. This means that the low ratio planetary unit is better able to carry a high Q-factor in relation to its weight than the high ratio planetary.

The lower curve on Fig. 5 shows an average curve for light weight planetary units. In individual cases, the actual weights may lie below the curve if the ratio is low and all possible efforts are made to reduce weight. The curve drawn is based on the assumption that a separate aluminum gear casing and a steel oil pump will be required as part of the set. Frequently an engine can be designed so that the planetary gear set will be housed within the casing of the engine. Obviously, a design along this line will show a gear weight that lies below the curve. Also, in some applications, weight is not too important, so thin steel casings are used and the gears and shafts are hollowed out to only a moderate degree. Such designs can be expected to weigh more than the lower curve on Fig. 5 indicates.

Sample Problems

The practical use of material presented in this article can probably be best demonstrated by considering some sample problems. For instance, suppose that a designer requires a gear unit having the following specifications:

Rating—100 hp.
Input Speed—2,000 rpm
Output Speed—500 rpm
Application—Gas turbine starter
Design Requirements—Small space available to mount starter necessitates compact, lightweight design. Intermittent service amounting to less than ½ hr per day. Unit must be quickly replaceable in case of trouble.

The gear set required will have a 4 to 1 ratio. The first step will be to determine the ratio factor $(m_g+1)^2 \div m_g$. For convenience, ratio factors for ratios between 1 and 10 have been tabulated in Table III. For a 4 to 1 ratio, the factor is 31.250. The Q-factor can be calculated by dividing the horsepower by the pinion speed and multiplying by the ratio factor. Thus, the Q-factor is $100/2{,}000$ multiplied by $31.25 = 1.56$.

Since compact size and light weight are of vital importance in this application, it is necessary to use hardened gearing loaded to a 500 K-factor or higher. Going to Fig. 5, the single pinion and gear curve for a light-weight design shows a weight of approximately 80 lb for a Q-factor of 1.56 while a planetary light-weight design for the same Q-factor shows a weight of 30 lb. It might be possible to carry a greater load than that equivalent to a 500 K-factor on a single pinion and gear design, but it is doubtful if the K-factor could be increased sufficiently to decrease the weight to that of a planetary gear set. Also, the planetary design is inherently more compact than a single pinion and gear design. If the design of the gas turbine is such that it will provide support, lubrication and part of the casing for this unit, it might be possible to make the design for appreciably less than 30 lb. The exact weight, of course, could only be determined by having a competent gear designer design the unit exactly for the particular application.

Suppose that a much larger, higher speed unit is desired for the following application.

Rating—6,000 hp.
Input Speed—10,000 rpm
Output Speed—1,800 rpm
Application—Turbine driving generator
Design requirements—Gear must be quiet and capable of many years service without repair. Size and weight not too important; unit will usually carry full load 24 hours a day.

The Q-factor for this application is 30.3. Since this is a high-speed set that must operate continuously, reliability and quiteness are important and size and weight are secondary considerations. Therefore, the teeth of the gear unit could be soft enough to permit ready machining after hardening. The K-factor would have to be low enough so that the unit would have sufficient margin to compensate for dynamic loading effects due to speed and size and also to compensate for momentary overloads. For a high-speed unit of this type, a K-factor of

Table III—Gear Ratio Factors for Single-Reduction Gear Sets

Speed Ratio (m_g)	Ratio Factor $(m_g+1)^2 \div m_g$	Speed Ratio m_g	Ratio Factor $(m_g+1)^2 \div m_g$	Speed Ratio m_g	Ratio Factor $(m_g+1)^2 \div m_g$	Speed Ratio m_g	Ratio Factor $(m_g+1)^2 \div m_g$
1.00	8.000	2.50	17.150	4.6	38.177	6.7	68.139
1.05	8.205	2.60	17.945	4.7	39.403	6.8	69.787
1.10	8.419	2.70	18.760	4.8	40.648	6.9	71.455
1.15	8.642	2.80	19.597	4.9	41.914	7.0	73.143
1.20	8.873	2.90	20.454	5.0	43.200	7.1	74.851
1.25	9.112	3.00	21.333	5.1	44.506	7.2	76.579
1.30	9.359	3.10	22.232	5.2	45.832	7.3	78.327
1.35	9.613	3.20	23.153	5.3	47.179	7.4	80.095
1.40	9.874	3.30	24.093	5.4	48.541	7.5	81.883
1.45	10.142	3.40	25.054	5.5	49.931	7.6	83.692
1.50	10.417	3.50	26.036	5.6	51.338	7.7	85.520
1.55	10.698	3.60	27.046	5.7	52.765	7.8	87.368
1.60	10.985	3.70	28.060	5.8	54.212	7.9	89.237
1.65	11.278	3.80	29.103	5.9	55.679	8.0	91.125
1.70	11.578	3.90	30.166	6.0	57.167	8.5	100.86
1.75	11.884	4.0	31.250	6.1	58.674	9.0	111.11
1.80	12.195	4.1	32.354	6.2	60.201	9.5	121.86
1.85	12.513	4.2	33.478	6.3	61.749	10.0	133.10
1.90	12.836	4.3	34.623	6.4	63.316		
1.95	13.165	4.4	35.787	6.5	64.904		
		4.5	36.972	6.6	66.511		
2.00	13.500						
2.10	14.186						
2.20	14.895						
2.30	15.625						
2.40	16.377						

about 100 would be reasonable. The curve for 100 *K*-factor loading on Fig. 3 gives an approximate weight for the unit of 12,000 lb. This weight would have to be considered approximate, since it depends on whether the designer chose a cast construction or a fabricated construction, and also on whether or not the gear webs and rims were made thick or thin.

Individual gear units from different manufacturers might be as heavy as 15,000 lb or might run as light as 8,000 lb. As in the case of the first problem, the exact weight could only be determined by having a competent gear designer design a unit for the particular application.

Double Reduction Gear Sets

The data presented in this article is intended primarily for single reduction gear sets since a *Q*-factor cannot be legitimately used to cover the complete ratio of double or triple reduction units. However, a *Q*-factor can be calculated to cover each step in the reduction, and the resultant weights added together to determine the total gear weight. This total, however, would probably be more than the actual weight since double reduction units usually share the same casing. Also, double reduction designs lend themselves quite conveniently to twin drives, in which one pinion drives two gears, or to other special designs that reduce weight. As just indicated, though, the data can be of some minor assistance in estimating double-reduction gear weights since it can be used to establish a ceiling weight that would represent the weight of two single-reduction gears connected together to do the double reduction gear job.

Chromium Plate Affects Fatigue Limit of Steels

NEW DATA on the effect of chromium plating on the fatigue limit of aircraft steels are now available as a result of an extensive study conducted recently at the National Bureau of Standards.

In this investigation, sponsored by the Navy Bureau of Aeronautics, specimens about $\frac{1}{4}$ in. in diameter were machined from three lots of SAE X4130 rod and one lot of 6130 rod. The X4130 steel was either normalized to a Rockwell hardness of 90-B or quenched and tempered to a hardness of about Rockwell 40-C, while the 6130 stock was quenched and tempered to a 33-C Rockwell hardness.

After grinding, polishing, and chromium-plating, the specimens were subjected to fatigue tests in an R. R. Moore type of rotating-beam machine operating at 1,800 or 3,600 rpm. Eight or ten specimens were usually required to obtain the fatigue limit for any one set of conditions.

In all cases, chromium plating was found to reduce the fatigue limits of the steels studied, although the effect was less pronounced under some conditions than others.

In general, the reduction in fatigue limit increased with greater hardness of the steels. For material of a given hardness, the fatigue limit decreased with increased temperature of the plating bath.

It was discovered that the fatigue limits of specimens plated and subsequently ground to remove a part of the plating were equal to or greater than those initially plated to the same thickness as the ground specimens and tested as plated.

Other experiments showed that interruptions of the plating process did not reduce the fatigue limit of the specimens provided proper precautions were taken for continuing the plating.

Chromium-plated materials often are heated to temperatures between 90 and 200 C to improve their mechanical properties by expelling the hydrogen deposited with the chromium. Hence, a systematic study was made of the effect of heating on the fatigue limit of chromium-plated steel.

Results showed that the fatigue limits of quenched and tempered specimens heated after plating decreased to a minimum value for some heating temperature between 100 and 300 C and thereafter increased with higher heating temperatures. Fatigue limits of specimens heated for one hour at 440 C were, in some cases, 87.5 percent of that of the unplated steel, whereas fatigue limits of specimens plated but not heated, and of specimens heated one hour (in air) at 193 C, were only about 68 or 27 percent, respectively, of the unplated steel.

Three possible causes for the adverse effect of chromium plating on the fatigue limits of the steels were: embrittling effect of hydrogen deposited with the chromium, cracks in the chromium and residual stresses.

However, it was shown that there was no simple relationship between the fatigue limit and the amount of hydrogen remaining in the chromium after a baking treatment.

Further experimental evidence indicated that cracks present in the chromium were not the cause of the reduced fatigue limits of the plated steels.

It is generally agreed that residual stresses in a material markedly effect its fatigue limit. Thus, in steel, compressive stresses, such as are produced by shot peening, increase the fatigue limit; tensile stresses have the opposite effect.

To show the presence of tensile stresses in electrodeposited chromium and the effect of heat treatment on these stresses, thin-wall tubes of annealed steel were chromium-plated and subsequently heated to different temperatures. "Tongues"—strips about $\frac{1}{16}$ in. wide and 2 in. long, with one end left attached—were then cut in the tubing to permit a qualitative evaluation of stresses in the chromium plate.

"Tongues" cut in plated tubing that had not been heated were found to bend slightly outward from the surface of the tube, indicating the presence of tensile stresses in the plate.

Baking the plated tubes at temperatures of about 200 C was found to increase further the tensile stresses in the chromium, as evidenced by the greater bending of the "tongue" away from the tube surface.

From these observations, it was concluded that the decreased fatigue limit accompanying heating of plated specimens at 200 C was caused by increased stresses induced in the chromium.

This conclusion has been further substantiated by experience showing that electrodeposited chromium subjected to a heating-and-cooling cycle increases in density and thereby contracts. Since no significant dimensional changes occur in the steel upon completion of the cycle, the steel tends to restrain the complete shrinkage of the chromium layer and thereby increases the tensile stresses in it.

If the chromium-plated steel is heated to a sufficiently high temperature (above 440 C), the contractive forces in the chromium produce sufficient tensile stresses to cause plastic flow or rupture of the chromium plate, thereby relieving the residual tensile stresses within. Thus, when the tubes were heated above 400 C and the "tongues" cut, the free ends were depressed below the surfaces of the tubes, indicating a release of the restraint in the steel initially caused by residual tensile stresses in the chromium.

THE DIMINISHING MECHANICAL COMPARTMENT THROUGH THE YEARS

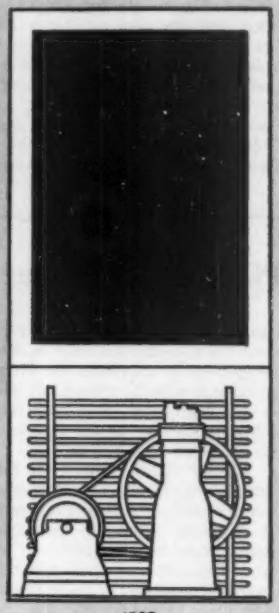
1928 Open compressor, belt-connected motor and plain tubing condenser occupied more than ⅓ total cabinet space.

1937 Adoption of hermetically sealed motor-compressor unit and fin type condenser made for compactness.

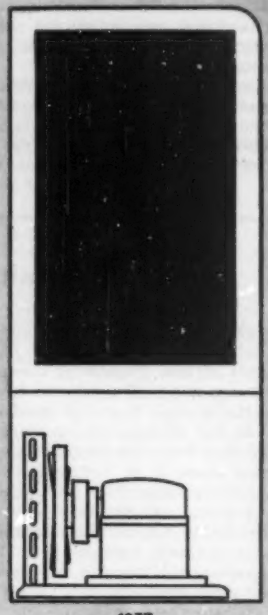
1939 Increasing condenser size made fan unnecessary. Mechanical unit was relocated to make room for bin.

1941 Condenser was laid flat and mechanical unit moved closer to the back.

1947 Stack type condenser and unsymmetrical unit housing made space available for insulating the storage bin.



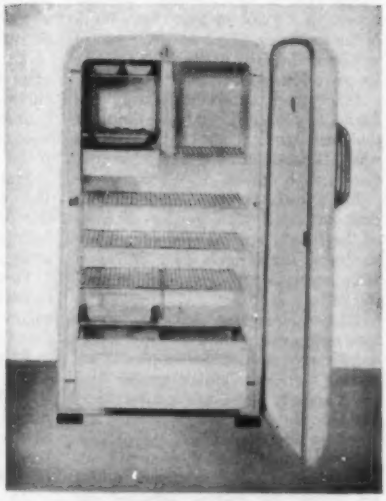
1928



1937

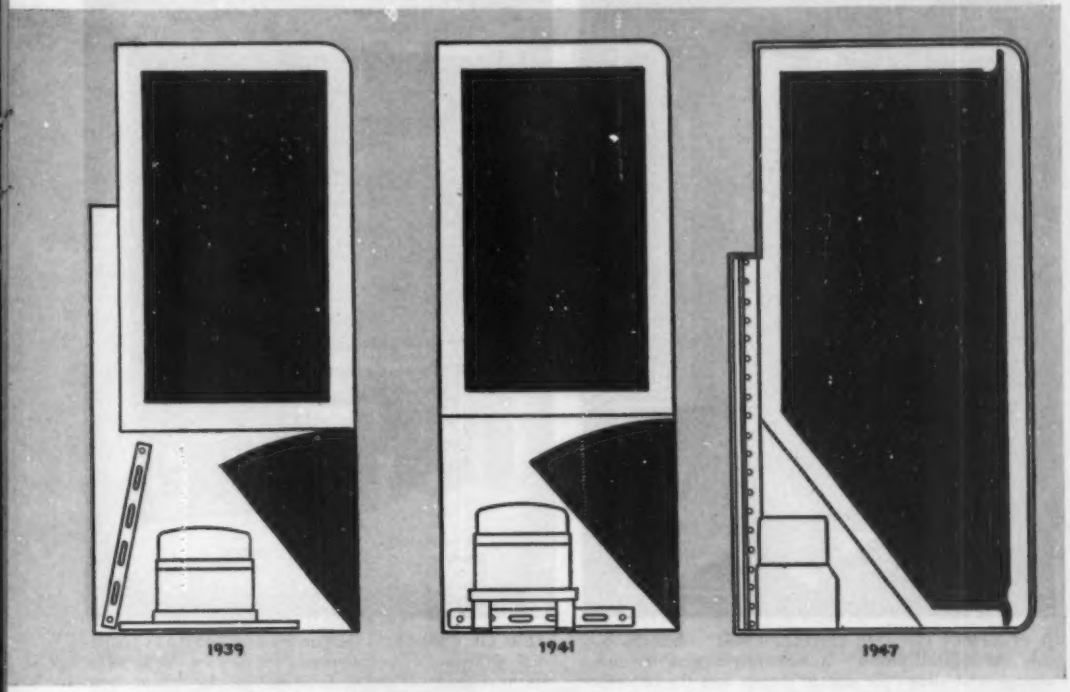
Suspension Of Compressor Unit Saves Space

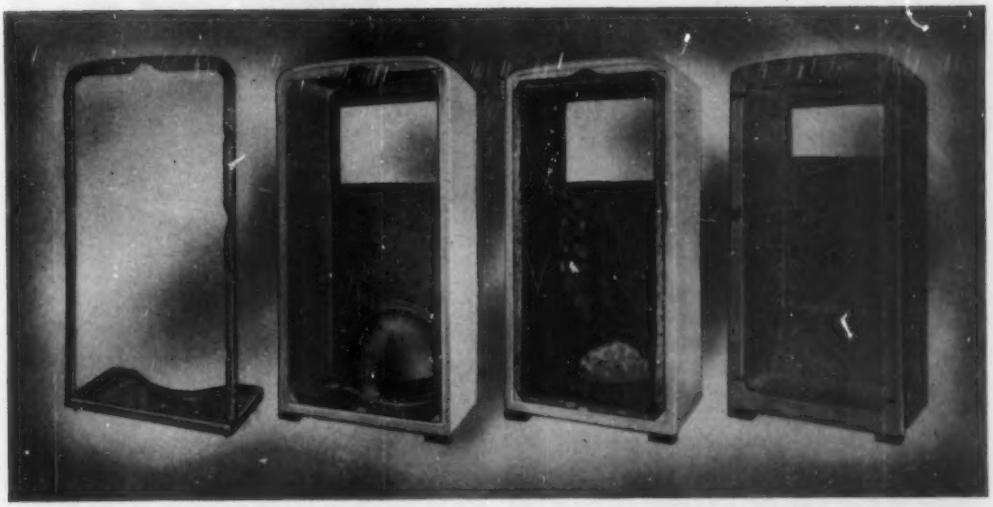
As evidenced by the above sketches, the principle trend in refrigerator design has been toward increased food storage space within limited cabinet size. In announcing their 1950 models, Kelvinator engineers claim they have contributed substantially to this trend. The model VM box has a 12 cu ft capacity—but cabinet size is the same as 6 cu ft refrigerators of years ago. A new mounting design for the sealed motor-compressor unit is the feature of the new line. The unit is suspended so that a portion of it is outside the cabinet proper. Besides increasing available cabinet space, the new mounting decreases noise and vibration and improves the cooling of the unit. Nash-Kelvinator is in Detroit, Michigan.



THE 1950 MODEL VM refrigerator has capacity of 12 cu ft. Crisper section has a full-size drawer replacing last year's tilting bin.

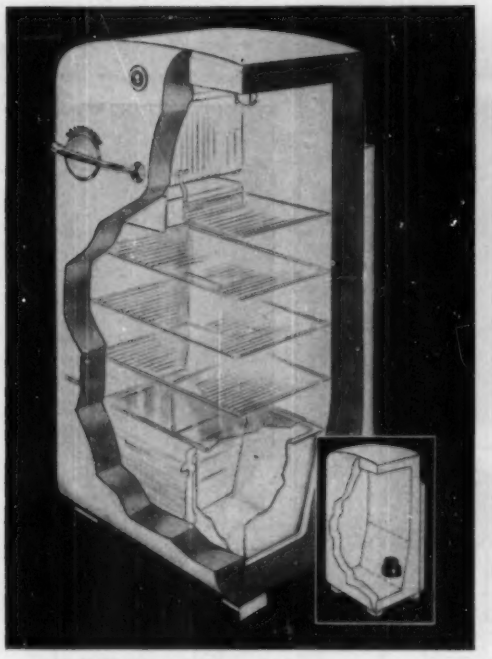
D E S I G N S



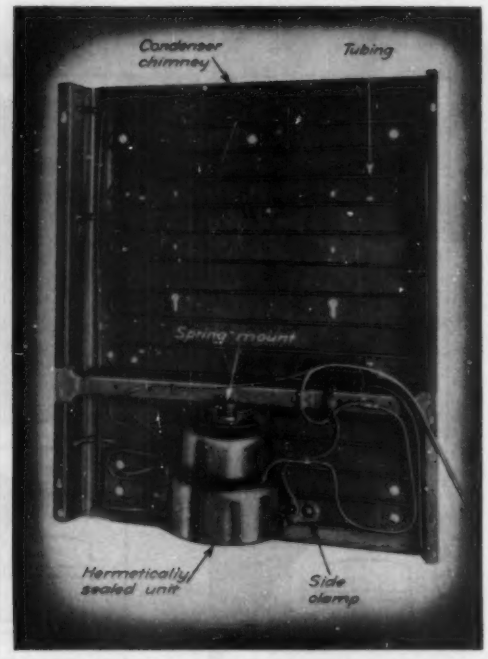


HALF-ROUND STEEL PAN encloses all that remains of the mechanical compartment. The protrusion of the compartment into the cabinet is even less evident after the insulation is applied. The insulation over the steel pan is compressed to minimize the bulge. All space within the one-piece steel liner is refrigerated. *(continued next page)*

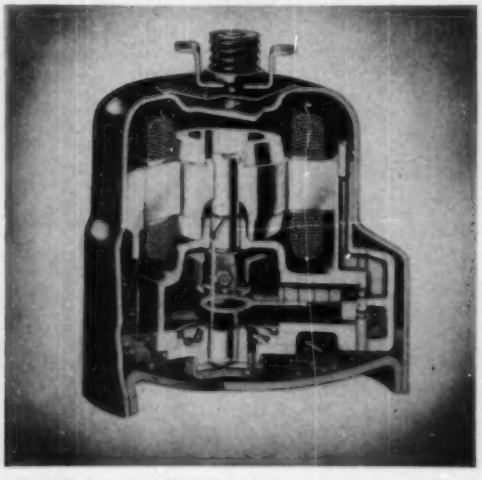
Refrigerator Design (continued)



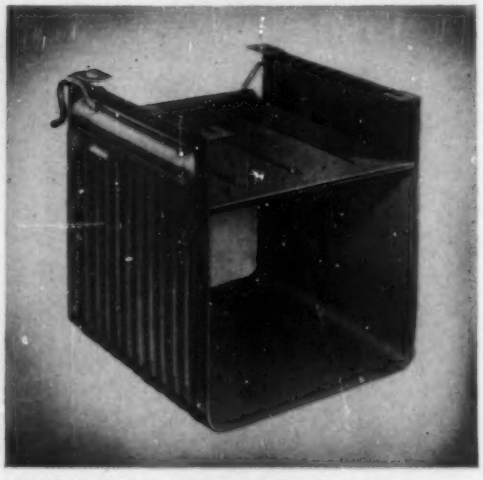
A PORTION OF THE SEALED UNIT is actually outside the cabinet proper. A new single-point mounting arrangement allows the unit to project into the condenser stack. In previous models, entire unit was within the cabinet and bolted down flat on the refrigerator base.



VIEW OF INSIDE of the condenser stack shows single-point spring suspension of the refrigeration unit. In addition to releasing space for food storage, the change from bottom to top mounting decreased transmission of sound. Rubber snubbers in side clamp limits movement of unit.



MOTOR-COMPRESSOR UNIT is assembled compactly within the outside shell. Shell has eccentric shape so outer side fits flush against condenser stack.

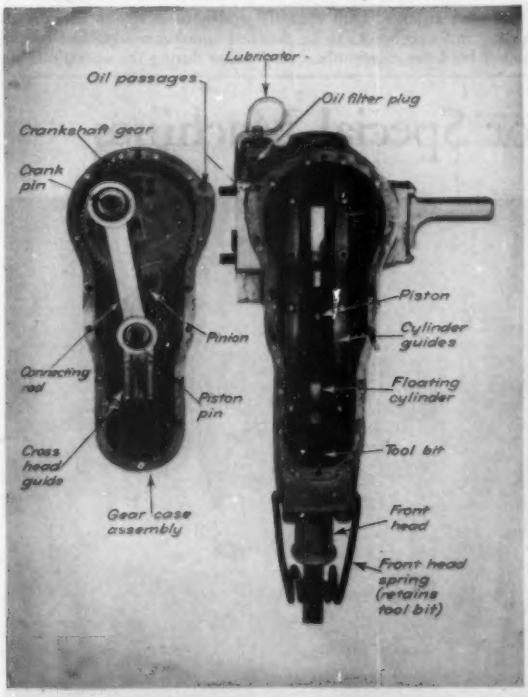


FREEZING UNIT is of stainless steel, double wall construction. Outer wall is corrugated to provide channels for flow of refrigerant around unit.

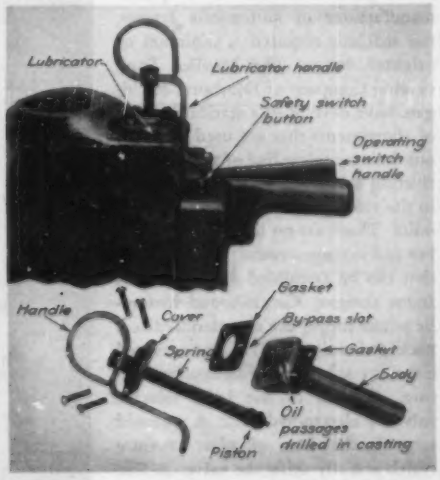
High-Cycle Motor Drives Paving Breaker

To overcome the problems of vibration and weight, engineers of the Homelite Corporation selected a high-cycle motor for their new electric paving breaker. This type of motor has no brushes, which are subject to excessive sparking under heavy vibration. Also, the weight of the high-cycle motor is 1/3 that of a 60 cycle squirrel cage motor of equal output. Power supply for the breaker is 220 v, 180 cycle, 3 phase alternating current. Retaining rings are used whenever possible in place of separable type fasteners which tend to loosen in impact service. To isolate vibration from motor and gearing, power is delivered to the tool through an air cushion. A safety circuit prevents operation of the breaker unless properly lubricated. Homelite is in Port Chester, New York.

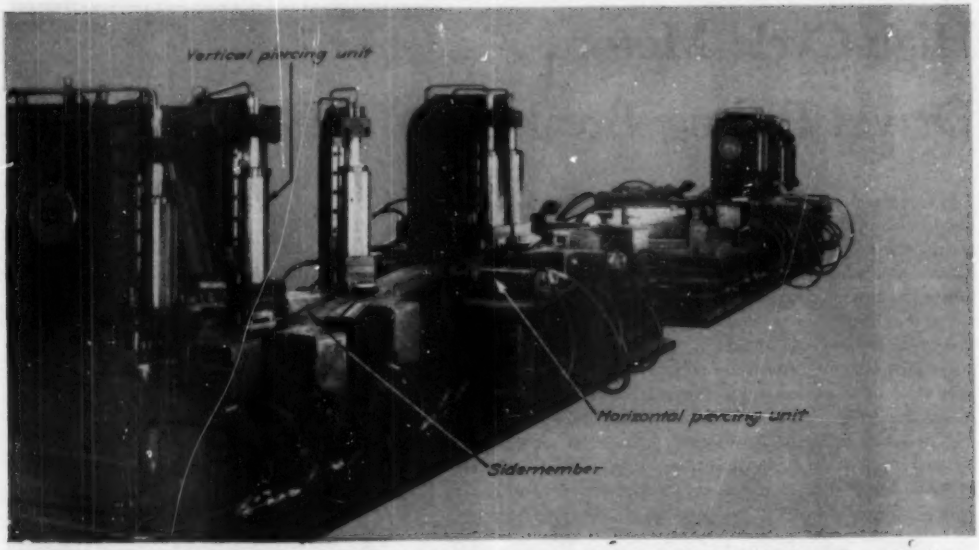
A 6 HP GASOLINE ENGINE generator set supplies electrical power for operation of the paving breaker. This highly portable set replaces the compressor outfits required for pnuematic hammers. Besides high-cycle current, generator delivers 110 v direct current for small tools and floodlights.



THROUGH REDUCTION GEARING, high-cycle motor drives the crankshaft gear at 700 rpm. The connecting rod imparts a reciprocating motion to the piston, which compresses air alternately in the top and bottom ends of the floating cylinder. Air compressed on the down stroke of the piston forces the cylinder against the tool with a hammer blow.



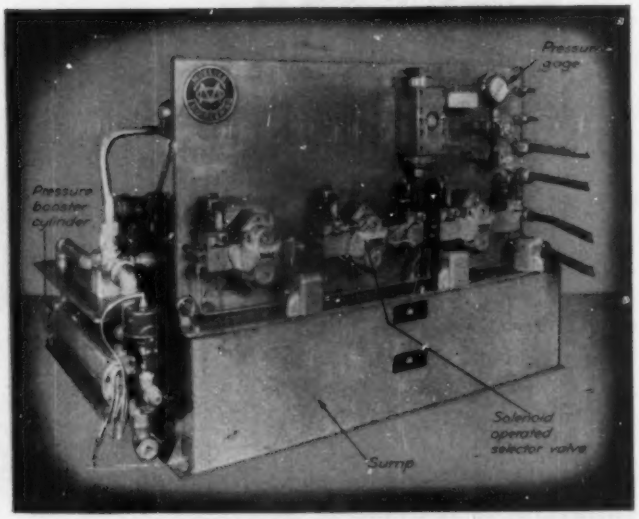
PULLING UP THE LUBRICATOR PISTON causes oil to be drawn through a check valve from a reservoir into the body. The spring loaded piston forces the trapped oil into the lubricating passages of the breaker. At the end of its stroke, the piston trips a switch, opening the power circuit.



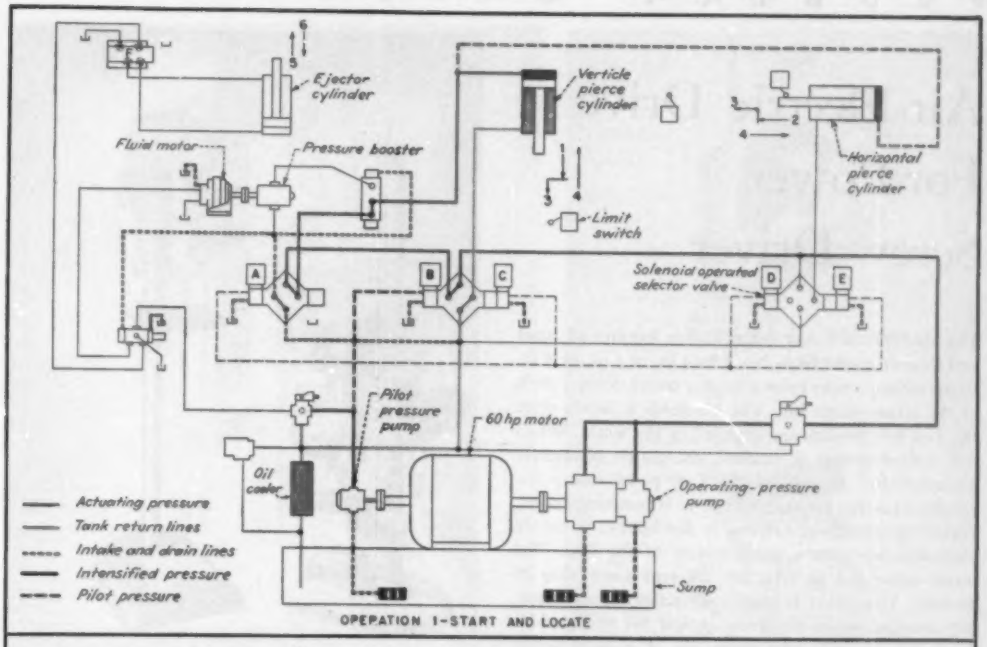
THIS MACHINE PUNCHES all required holes in an automobile frame side-member. The two-section machine consists essentially of 16 hydraulic piercing units. These are arranged both vertically and horizontally so that flange and web holes can be punched simultaneously. Die blocks hold the sidemembers in position during the operation.

Standard Parts for Special Machines

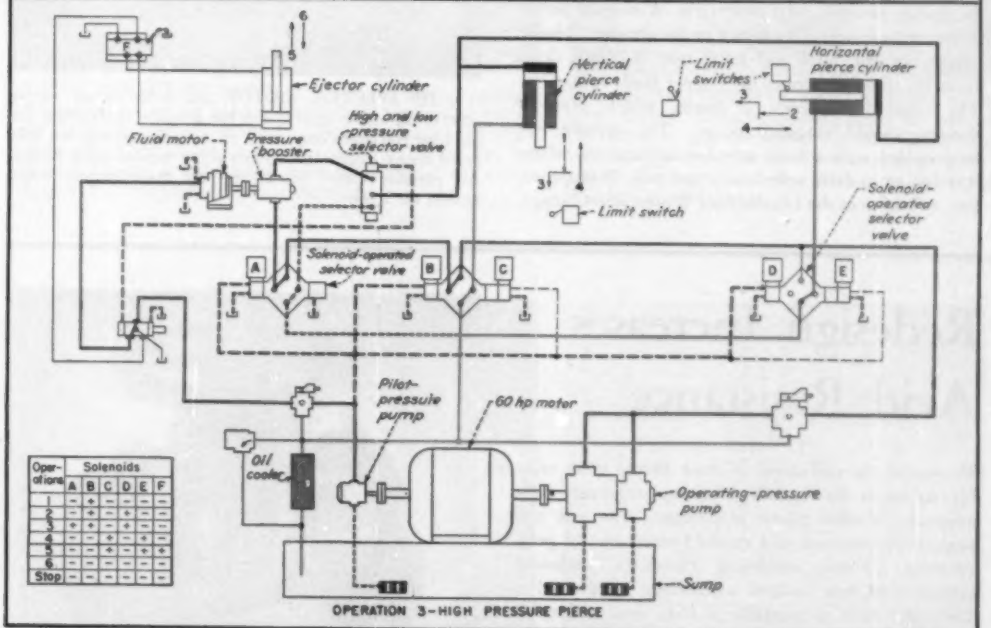
Although custom-built for a specific manufacturer of automobile frames, this machine required a minimum of original design. The Mueller Engineering Company of Dearborn, Michigan, have developed a standard group of components that are used throughout their complete line of piercing and riveting machines. Holes are punched in the steel rails by hydraulic piercing units. There are no limits to the number and arrangement of piercing units that can be assembled to suit various frame designs. Controls and hydraulic power supply are also standardized, packaged units. Valves are operated either by solenoids or hydraulic pressure. Control of the large selector valves is electro-hydraulic. A solenoid controls the flow of pilot pressure which actually shifts the valve. A 5 to 1 ratio booster steps up hydraulic pressure to 10,000 psi for the piercing operation.



POWER UNIT for the machine includes electric pumps, solenoid-operated selector valves and an oil sump. Sequence of operation is automatic. Behind the steel panel in the photo above is a 60 hp motor with a double ended output shaft. This drives the main pump, rated at 77 gpm at 1,000 psi. A 7 gpm, 400 psi pump supplies pilot pressure and operates ejecting cylinders.



OPEPATION 1–START AND LOCATE



Operations	Solenoids A	B	C	D	E	F
1	–	+	–	–	–	–
2	–	+	–	+	–	–
3	+	–	–	+	–	–
4	–	–	+	–	+	–
5	–	–	+	–	–	+
6	–	–	–	–	–	–
Stop	–	–	–	–	–	–

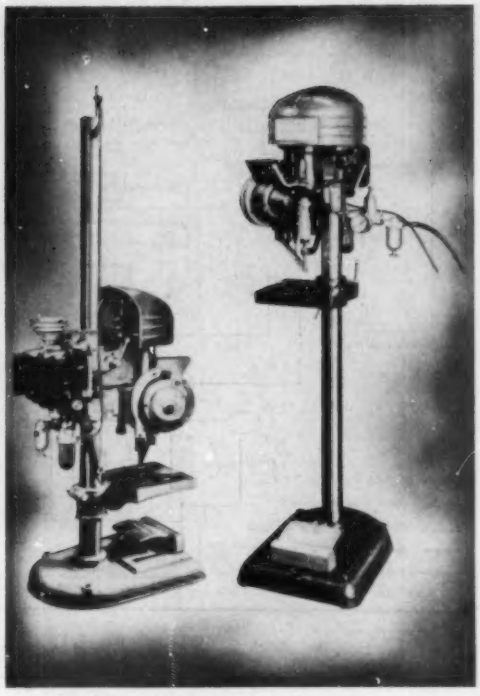
OPERATION 3–HIGH PRESSURE PIERCE

AT THE START OF THE OPERATION, solenoid B of a 4-way selector valve is energized through an electric timing circuit. This admits pressure to all cylinders and opens the return side of all vertical cylinders to sump. Vertical pistons operate, locating the part in position. Near the end of their stroke, the vertical pistons close limit switches, energizing solenoid D and opening the return lines of the horizontal cylinders. When the horizontal pistons reach their operating position, they trip a limit switch, which sets up conditions for the intensified press.

Vickers Incorporated, Detroit

Air-Electric Drive For Power Screw Driver

The Shakeproof Power Screw Driver handles all types and sizes of screws from No. 1 by $\frac{1}{8}$ in. to $\frac{1}{4}$ in. by $\frac{1}{4}$ in. In operation, screws from a hopper travel down a track to the screw driver bit. The bit holds it firmly until the first few threads are engaged in the work. When the desired torque is reached, the clutch disengages automatically. Release of the foot pedal causes the spindle to return for another screw. If jamming occurs, caused by wrong-sized screws in the hopper, a simple mechanism permits a quick release of the jam. The screw driver can be reset for different screw sizes in 20 min. The driver is electro-pneumatically operated. Air pressure moves the screw against the work, while an electric motor is used to drive it. A stepped pulley V-belt drive connects the motor to the spindle. Spindle speeds are 680, 1,250 and 2,400 rpm. A V-belt drive from the spindle operates the hopper feed mechanism. The latter incorporates a clutch, which prevents damage should clogging occur. The spindle can be provided with a limit stop for applications where it is desired to drive screws only part way. Shakeproof, Inc., a division of the Illinois Tool Works, is in Chicago.

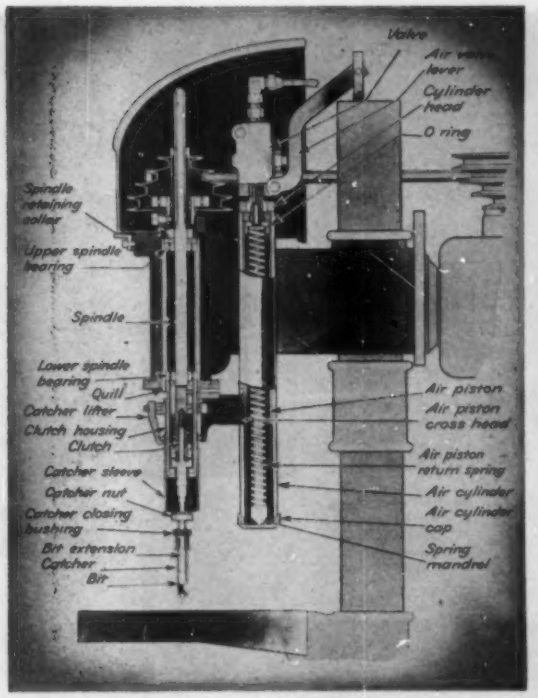


A $\frac{1}{4}$ HP ELECTRIC MOTOR and a 50 psi air supply powers the screw driver. For the average application, the machine consumes one cu in. of air. Depressing the foot pedal opens a valve that admits air to the operating piston. Air pressure moves piston and the main spindle down against the screw.

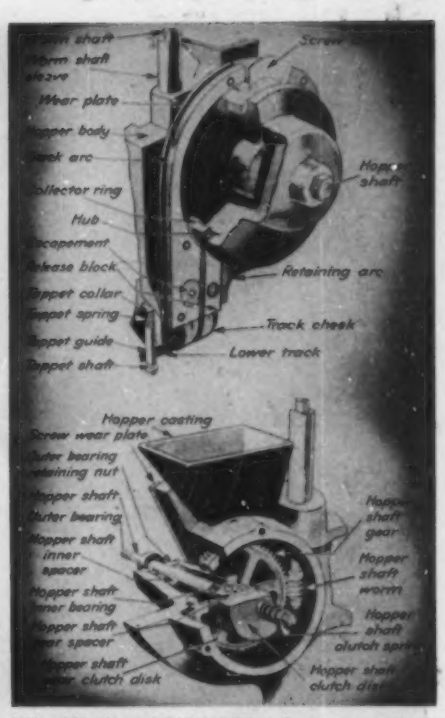
Redesign Increases Acid Resistance

To extend the usefulness of their Model 6600 valve for corrosive fluids, Hills-McCanna engineers have adopted a flexible plastic diaphragm. The new diaphragm is composed of a special formulation of polyethylene. Strong oxidizing chemicals, including sulfuric acid, are handled successfully by the valve. The valve body is available in iron, steel and other materials and may be lead or glass lined. In addition to using the plastic diaphragm, the designers have provided a safeguard against stem overtravel and added seals to prevent fluid leakage should diaphragm rupture. The Hills-McCanna Company is in Chicago.

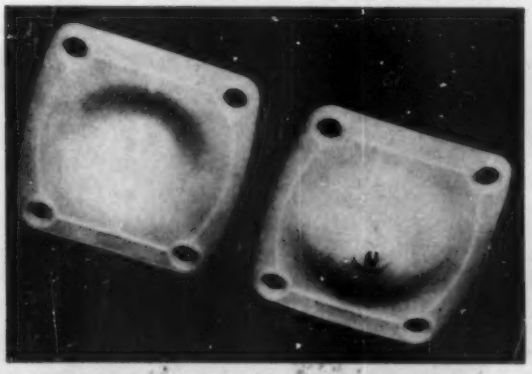
TO SAFEGUARD DIAPHRAGM, travel stop has been added to valve. Collar on the stem bears against the handwheel retainer nut when the valve is closed. This prevents crushing of the diaphragm under excessive torque.



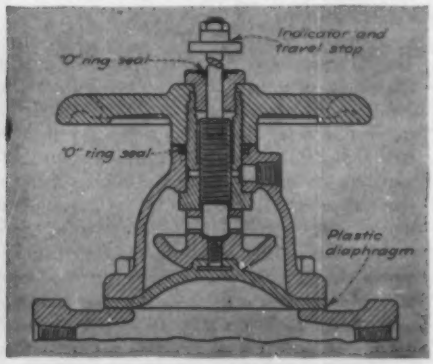
WHEN THE SCREW MEETS the work, the clutch is engaged and the bit rotates the screw. After a few threads have entered the work, the catcher is released. The spring-loaded jaw clutch disengages when its torque setting is reached. When the foot pedal is released, spindle retracts resetting the catcher and a screw is again fed to it for repetition of the cycle.



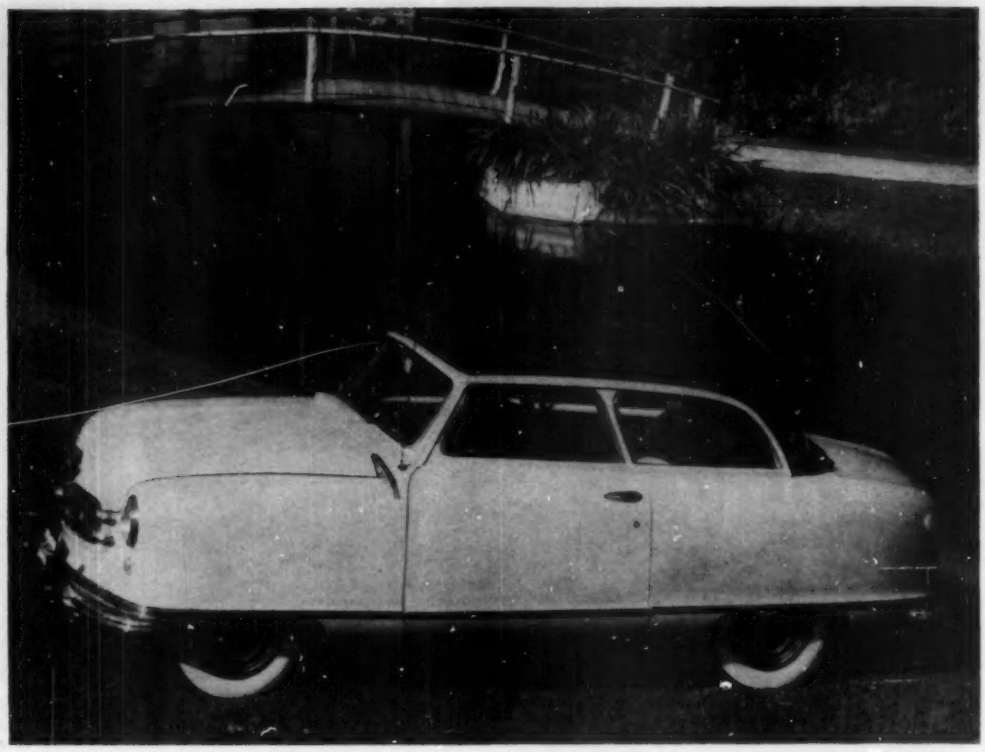
ESCAPEMENT MECHANISM feeds screws singly to the catcher. A sliding bushing causes the jaws of the catcher to grip the screw. Slotted collector ring positions the screws ahead of the escapement mechanism. The hopper shaft that turns the collector ring is driven by a worm gear.



PLASTIC DIAPHRAGM regulates fluid flow through the valve. New diaphragm is more resistant to oxidation than natural and synthetic rubbers used formerly. Valve successfully handles concentrated sulphuric acid (66° Baume).

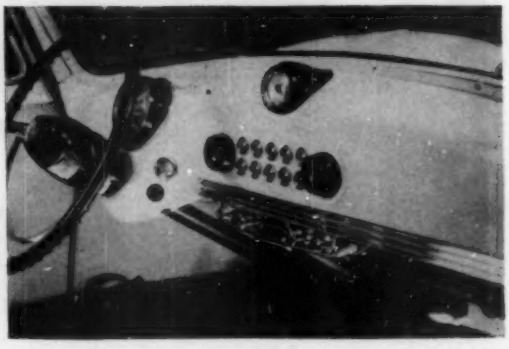


SPECIAL SEALS in bonnet assembly are new feature. These are required to make it impossible for acid to spray out of the bonnet should mechanical damage be done to the diaphragm.

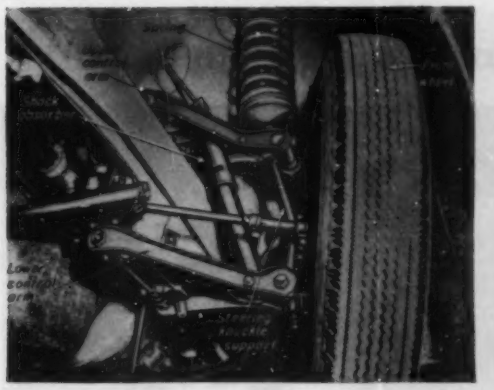


Unitized Construction Extended To New Short Wheelbase Convertible

The five-passenger "Rambler" convertible is the forerunner of a new series of 100 in. wheelbase Nash cars. Designed to compete in the lowest-priced automobile field, the car has two heavy steel roof rails framing the tops of the side windows. The roof rails are integral parts of a unitized body and frame structure and are intended for passenger protection and car rigidity. Departing from conventional practice, the car does not use a pantograph mechanism for operation of the fabric top. Instead, the top is fastened to steel runners that slide along tracks in the roof rails. Nylon-covered steel cables, driven by an electric motor, pull the top into the open or closed positions. The car also features a new front end suspension in which the coil springs act directly on the steering knuckle supports. This takes the car load off the control arms.

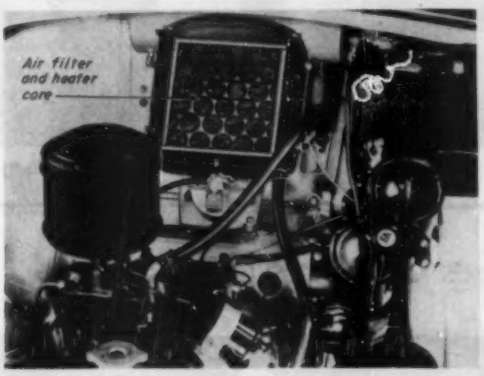


INSTRUMENTS are in compact cluster on a protruding section that conceals the steering column. Ten circular louvers replace the conventional radio grille.

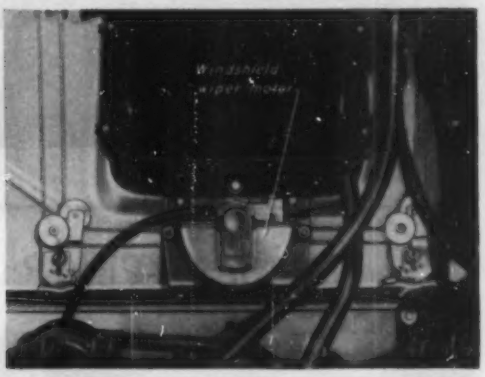


LIGHTER CONTROL ARMS now function only to keep wheels in alignment. Springs act directly on the knuckle supports, so arms no longer carry the car weight.

DEFROSTER DUCTS are integral with fan housing. The five-bladed fan sets up axial air flow into the passenger compartment and radial flow for defroster ducts.

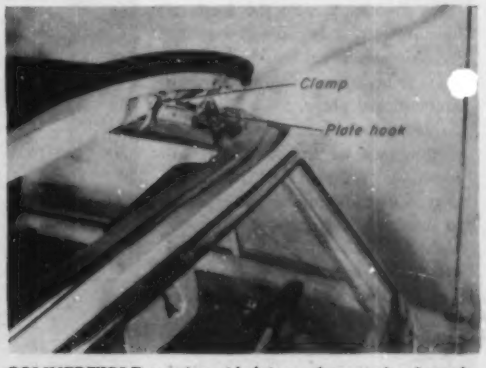


HOT WATER CORE and air filter for the car's heating system is located in the engine compartment. This increases legroom available for front seat passengers.



TO MAKE ROOM for the heater unit, the windshield wiper motor is mounted on the engine side of the firewall. Maintenance of wiper motor and cable is facilitated.

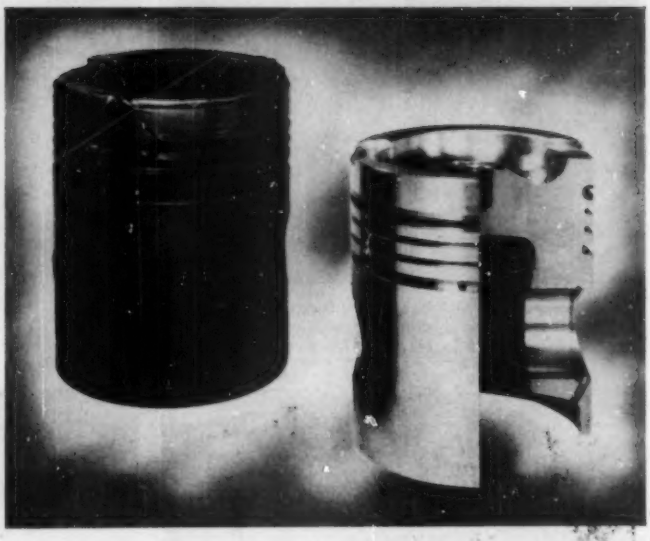
PANTOGRAPH LINKAGE, customarily used for operation of a convertible top, is absent. Top is supported by four steel crossbars that slide along the roof rails.



CONVERTIBLE top is guided into place at the front by two plate hook engaging pins in the rails. Clamps at each side fasten top to the windshield header.

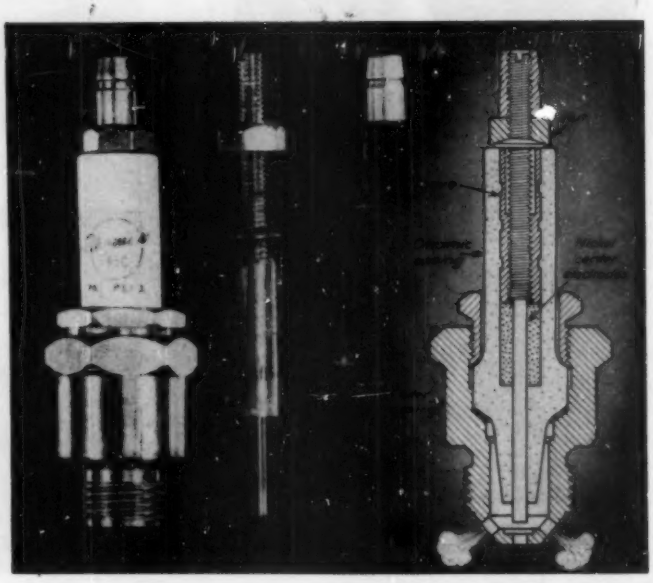
Bi-metallic Construction Extends Piston Life

The ring area of aluminum alloy pistons is subject to a high rate of wear. As evidenced by the piston on the left in this picture, the top ring groove is especially affected. It is closest to the hot gases, receives the least lubrication and is exposed to dust admitted through the intake. The United Engine and Machine Company of San Leandro, Calif., overcomes this problem by adding a ferrous metal insert to the top ring groove. The A1-Fin process, developed by Fairchild Engine and Airplane Corp., is used to bond the insert to the aluminum alloy. The top ring groove of the bi-metallic piston has substantially the same wear resistance as the grooves in a cast iron piston.
The insert is cast into place on the piston before final machining.



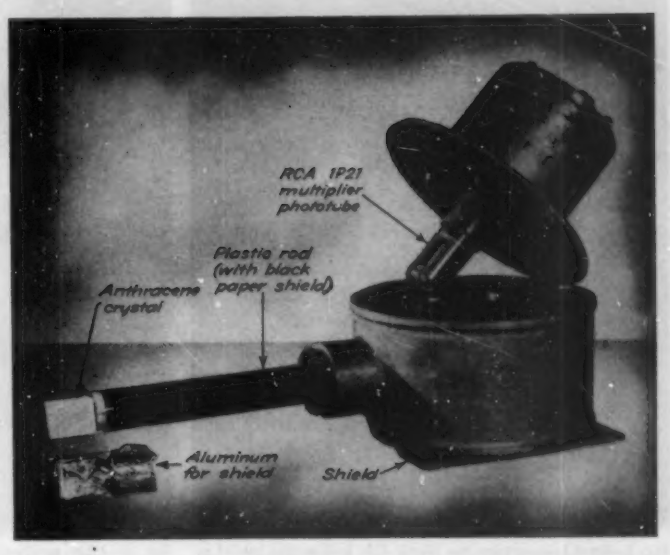
New Spark-Plug Raises Compression Ratio

Feature of this rustproof sparkplug is the baffled firing chamber. On the compression stroke, gases are forced through 5 orifices in the baffle. When the spark occurs, these gases ignite first and are propelled from the chamber in the form of burning jets. It is claimed that the jet action causes the main body of gases to burn more completely than conventional plugs. Since the baffle displaces about 2 cc of the cylinder volume, use of the new plug increases compression slightly. Explosion of gases within the baffle tends to force out oil or foreign matter and thus prevents fouling. Monel and nickel are used for all metal parts except the ignition wire nut, which is brass. This choice of materials makes the sparkplug completely rustproof. The Thomas Automotive Products Manufacturing Co. of Rockford, Ill., makes it.



Plastic Rod Conducts Light to Phototube

Heart of the University of Rochester cyclotron is the multiplier phototube that is used to measure radiation. To avoid the problem of locating the test device within the cyclotron itself, designers utilized a light conductive rod of acrylic plastic. This rod connects the anthracene crystal to the phototube, which is housed in a light-tight box outside the cyclotron. Flashes of light produced when radioactive particle radiation strikes the crystal are conducted down the rod to the phototube. In this way, radioactivity is converted to a measurable electrical quantity. To keep room illumination out of the system, the plastic rod is covered with a black paper shield which can be penetrated by the radio-active particles. RCA makes the phototube.



Induction Brazing Lowers Convector Cost

This convector air chamber, originally a heavy grey iron casting, now consists of 2 stampings and 2 screw machine parts silver brazed together. Results of the redesign are improved appearance, reduced size and weight, faster production and a 15 percent decrease in cost. The stamped chambers equal the original castings in strength and air-tightness. Also, they are corrosion resistant. The chamber body consists of 2 stampings, which are identical except one is spread to receive the other. There are 3 joints in the assembly and these are induction brazed in one operation, using 2 washers and one ring of brazing material. The chamber is finished in a bright dip. Young Radiator Company of Racine, Wisconsin is the manufacturer. Handy & Harman supplies the brazing washers and rings used in the assembly.

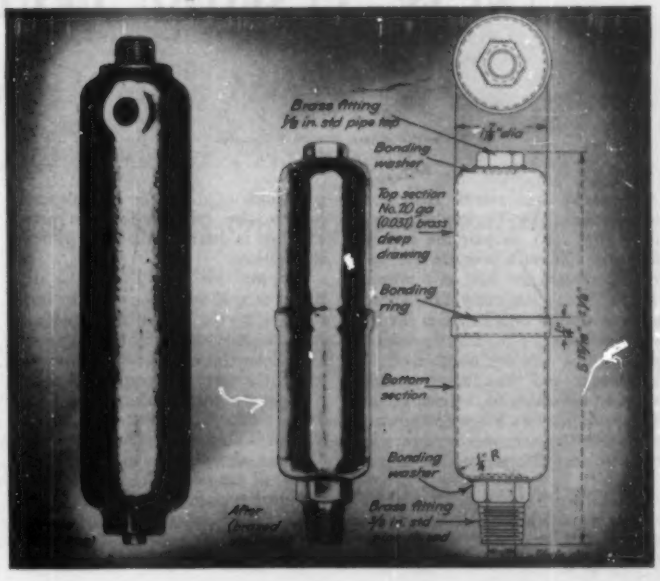


Fig. 1—Steel box encloses the plastic clay half-section model of valve. Box is mounted in air supply line for testing. Plexiglas cover enables designer to observe air flow during the test runs.

Fig. 2—After modifications and tests are completed, plaster of Paris is poured into the test box. This provides permanent model of the valve contours required for minimum pressure loss.

New Testing Techniques in

E. B. POOL
Research Engineer, Edward Valves, Inc.

ANY VALVE HAS THREE FUNCTIONS to perform: (1) To stop or reduce fluid flow; (2) to pass the required flow with minimum pressure loss; and, (3) to contain the fluid as a pressure vessel. There are many fundamental types of design to accomplish the first function such as gate, disk, flexible diaphragm and rotating plug. Each has advantages and disadvantages which affect its suitability for a given service. These are more or less well known so the valve engineer can readily select the type on which to base his design.

Designing for Least Pressure Loss

The two other functions involve considerably more design effort. But the new techniques are intended to save much of this. For example, the correct valve contours for least pressure loss is determined simply by test observations.

Suppose that the valve to be designed is a 10 in. globe valve to conform with the American Standards Association 900 lb SP specification. This determines the basic port diameter of the valve and its overall length. It is assumed that the stem is at 90 deg to the pipe axis, and that the plane of the seat is on the pipe centerline. The diameter of the seat is to be the same as that of the port. The passages connecting the ports and the seat are to be developed primarily for low resistance to flow.

The complicated flow patterns set up by the irregular shapes makes theoretical analysis impossible. Trial and error is the only solution open to the designer. One possibility would be to work with actual valves. Knowing the basic dimensions given above and drawing on past experience, he can quickly design a valve which will approach to some degree the desired pressure loss characteristics.

When the first design is completed a prototype valve is made. The valve is subjected to alternate testing and modifications until it complies with the maximum value of allowable pressure loss.

Compressed air is the test fluid. This is metered through an orifice plate to the valve under test. The density of the air and its pressure drop are measured at both the orifice and the valve.

Fortunately, the theory of fluid dynamics permits the calculation of a

Fig. 3—Cardboard templates made from plaster of Paris model. These are used to make mold and core patterns for casting the valve prototype in steel. The thicknesses of metal are estimated.

Fig. 4—Subjecting actual valve to stress analysis. Results of this test show where metal is to be added or removed from the valve walls. Two techniques of stress analysis are used.

Valve Design That . . .

1. Cut Design Time in Half

2. Lead to Better Performance

3. Avoid Complicated Formulas

single coefficient expressing the pressure loss characteristics of a given shape from test data with one fluid, one density and one rate of flow. This coefficient may then be applied to wide ranges of fluids, densities and flow rates to determine pressure loss in the given shape under most service conditions. Thus, compressed air can be used in testing all types of valves for fluid or gas service.

The difficulties encountered in modifying shapes to obtain minimum pressure loss in actual valves are obvious. For each contour modification a pattern would have to be made and a casting poured and machined. Time and expense would prohibit testing sufficient shapes to arrive at the optimum.

Plastic Modeling Technique

Fortunately, it is unnecessary to work with actual valves. Instead, a symmetrical half of the valve shape is formed from a plastic material similar to modeling clay. A steel box contains the plastic model, as shown in Fig. 1. The steel box has the correct end to end dimensions with flanges for attaching to the test equipment. A steel seat is mounted on a metal diaphragm in the box. The entrance and exit pipes contain dividers so that there is no sudden contraction and enlargement of the flow stream upon entering or leaving the half model. The box is covered with a sheet of plexiglass clamped in place and thoroughly sealed. Only a few minutes are required to remove the cover, change the shape of the model, replace the

cover and test the effect of the change on pressure loss.

When this method was first attempted it was not certain that good correlation would be obtained between these half models and actual valves of identical design. Flow tests of many actual valves made from these models have shown repeatedly the reliability and accuracy of this method. It is further possible to construct models reduced in scale as much as one to three. This permits the design of many valves from the same box.

The merit of a given contour is judged by the measured coefficient. However, with the infinite variations in shape possible, random trial and error procedure is very time consuming. As aids in visualizing flow patterns, supplementary techniques have been employed. (1) Streamers attached to pins stuck into the model give the direction of flow at local points in the valve. (2) Chemical smoke is introduced into the flow stream through a small tube, giving visual flow patterns. (3) Exploration with a pitot tube gives relative air velocities. These methods suggest beneficial changes of shape, which are then proven by overall pressure loss measurements.

A universal shape for globe valves cannot be developed because end to end standards for various sizes and pressure classes destroy the geometric similarity. The method has also been applied to angle, gate, and rotating plug valves with equal success. With this technique, pressure loss in valves has been reduced as much as 50 percent.

Pressure Vessel Design

After the pressure loss tests are completed and the correct valve contour determined, plaster of Paris is poured into the cavity of the half-valve. The plaster model thus obtained is kept as a permanent record of the valve shape.

The next step is the construction of the valve body around this shape. Since the shape is not symmetrical, accurate stress calculations are impossible. To determine the necessary wall thicknesses at the various locations, the designer must refer to the results of experimental stress analyses on similar valve bodies. Therefore, much depends on the designer's skill in interpreting and applying these results to the new valve.

The first trial steel casting is built from the plaster of Paris model. In doing this, the plaster of Paris model is sectioned perpendicular to the valve axis at uniform intervals. The designer uses these sections for making templates, the inside contour of which represents the inside surface of the casting. The outside contour of these templates represents the outside of the casting and must be laid out by the designer. In choosing metal thickness, both the proper feeding of the casting to give sound metal and stress data accumulated on similar previous designs must be kept in mind. Flat or concave curvature on the exterior surfaces is to be avoided as high stresses result.

The templates are laid out to shrink scale so that they can be used directly by the pattern maker. The template spacing conforms to the thickness of the wood laminations to be used in building up the wooden pattern and the core box.

Experimental Stress Analysis

When the first casting from a new pattern is available, two techniques of experimental stress analysis are applied. First the brittle lacquer method is used to determine the location and direction of highest stresses on the outside of the casting when it is subjected to internal hydrostatic pressure. The brittle lacquer, sprayed on the casting, cracks at right angles to the direction of principle stress when a predetermined amount of strain occurs in the casting. Since the sensitivity of the lacquer depends on the temperature and humidity of the air as well as stress, the work is done in a room with year around air conditioning.

As hydrostatic pressure is applied in steps to the coated casting, the area of highest stress will crack first, then the next highest and so on. As cracks are noted, each area is marked with the pressure that caused cracking. Since the casting is designed for high temperature service where allowable stresses are low, a very sensitive lacquer must be used. Sensitivities of 0.0003 in. per in. of strain are desirable. This sensitivity is best achieved by coating the valve at a higher temperature than that at which it is to be tested. The room is slowly cooled until the desired sensitivity is reached. The sensitivity is measured by deflecting a calibration strip coated at the same time as the valve and following its temperature history.

The other method of experimental stress analysis uses wire resistance strain gages which are cemented to the valve body. As the body is strained by pressure, the gage wire is also strained. This changes its resistance. The change in resistance is measured on a sensitive potentiometer which is calibrated in microinches of strain. Through Young's modulus this may be converted into stress. The two methods are complementary. The strain gages are much more accurate than the brittle lacquer, but the latter method is usually used first to find the points of highest stress and the direction of the principle stresses.

Strain gages are also used on internal surfaces of the valve. High stresses are frequently encountered on the internal surfaces especially where small radii occur. Valves are also subjected to stresses from the adjoining pipe and from the closing of the valve disk. These have also been studied but the stresses are usually of much smaller magnitude than those caused by internal pressure.

Results of these stress analyses point the way toward leveling the stress distribution in the body by addition and removal of metal through pattern modifications. All such modifications are rechecked, both for pressure loss coefficient and stresses.

By redesigning valves for maximum utilization of metal, casting weights have been reduced as much as 25 percent.

Pressure Loss Apparatus and Calculations

The compressor used in the investigation described here delivers a maximum of 4,000 cfm of air at 100 psi. This capacity is sufficient for testing valves up to 14 in. in diameter.

The air is metered through a thin plate orifice. One of the seven available is selected as most suitable for the valve being tested. Three of these mount in the 4 in. line shown on the cover and 4 mount in a 1½ in. line for testing smaller valves. These orifices, accompanying flanges, flange pressure taps, and piping are constructed according to the ASME Research Reports on Fluid Meters. Therefore, the coefficients published therein can be used without further calibration.

The air first passes through a control valve, then it proceeds over to the right through the orifice line, in back of the instrument panel, then reverses direction, passes through the test valve or model, and exhausts through a duct under the floor. The instrument panel includes two 60 in. mercury manometers for measuring orifice and valve pressure differentials, an inclined water manometer for small valve differentials, and Bourdon gages for measuring pressure upstream from the orifice and the valve. The temperature of the air is measured by mercury thermometers in wells upstream from the orifice and the valve Simultaneous readings of pressure, temperatures, and pressure differential at both orifice and valve are recorded by the test and project engineers who

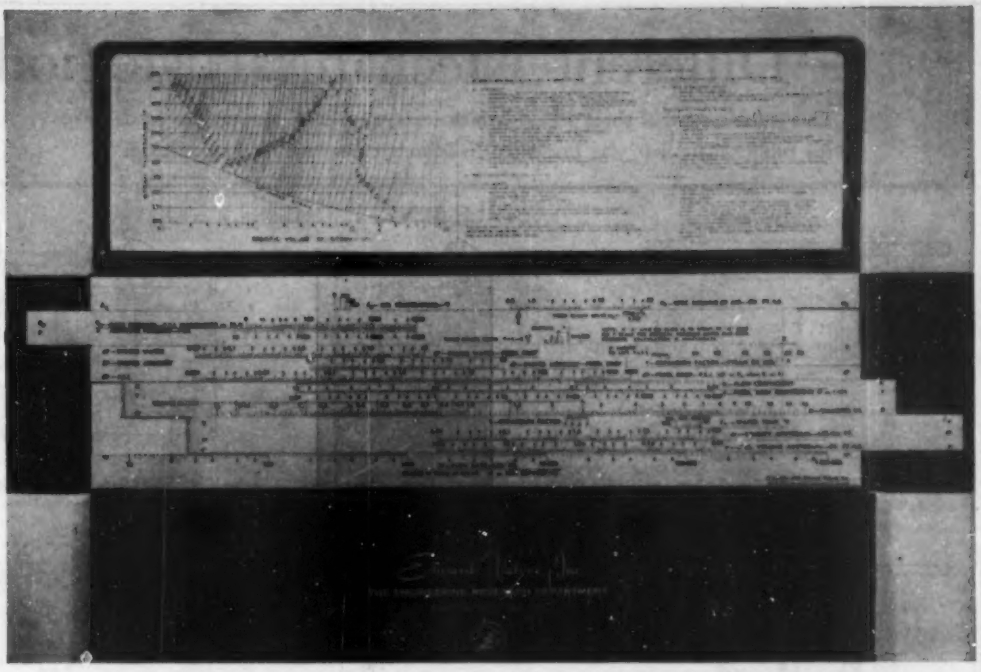


Fig. 5—Special slide rule for computing results of air tests and predicting pressure losses under service conditions.

are involved in the valve design.

Both the orifice and valve data may be analyzed with the same formula since both involve the same fundamental law:

$$W = 1891\ KD^2\ Y \sqrt{\frac{dP}{v}}$$

where

W = flow rate, lb/hr
dP = pressure differential orifice or valve, psi
v = specific volume of fluid upstream from orifice or valve, cu ft/lb
D = orifice throat diameter or valve port diameter, in.
K = flow coefficient, orifice or valve
Y = expansion factor, orifice or valve

For the orifice the specific volume is determined from the air temperature and pressure. The pressure differential and diameter are known. The flow coefficient and expansion factor are obtained from the ASME data. Therefore, the formula may be solved for the mass flow rate which is common to the orifice and the valve. The orifice coefficient varies slightly with Reynold's number but over the range of conditions used this variation is less than 1 percent from a mean coefficient for each orifice. This variation is therefore neglected.

For the valve some of the symbols are given a different interpretation. The pressure difference measured between taps 1 diameter upstream and 3 diameters downstream includes any significant recovery of pressure drop caused by turbulence. It is, therefore, true pressure loss. This is not the case with the orifice. The throat or minimum diameter in many valves is not a well defined dimension. Therefore, port diameter is used. The specific volume, usually different at the valve, is determined from pressure and temperature measurements. The expansion factor corrects for changes in specific volume of compressible fluids as the pressure drops through the valve. It has been empirically related to flow conditions. This relation is similar to that for orifices covered in the above reference. The flow rate is known from the orifice solution.

Thus, all of the variables in the formula applied to valves have been determined except K, the valve flow coefficient, for which the equation can be solved. Once this K has been determined from the air test, it may be used with the same equation to solve for pressure loss under any other flow conditions with air, water, steam, gas, etc. It has been found that this coefficient does not vary appreciably with Reynold's number over a minimum of 10,000 for almost all valves.

Air tests conducted with this apparatus have been checked against tests of valves in actual service. It was found that pressure loss registered when steam, water or oil was used agreed closely with the air pressure drop in the half-section model. This proves the adequacy of the analysis.

Soon after this test procedure and analysis were developed, it was found that the calculating time with a standard slide rule or calculating machine was several times greater than the testing time. Therefore, the special slide rule illustrated in Fig. 5 was developed. The conversion constants are built into the rule, and the full range of each variable is covered, automatically locating the decimal point. Two fixed scales and two slides solve the above formula. Auxiliary scales compute specific volumes of air and water and expansion factors. A chart on the cover gives specific volumes of steam. Calculating time was thus reduced to ¼ that previously required.

The success of these techniques in valve design indicates that consideration should be given to their application in other fields. Reduced-size, half-section models of cylinders, fittings, accumulators, etc. might simplify the design of these components.

Different Mechanical Methods

This is the second of three articles which feature types of connections used for tubing. The first was presented in March 1950 Product Engineering.

ATTACHMENTS

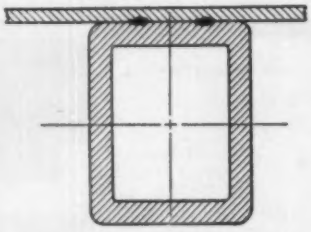


Fig. 1—Welded attachment of plates to tubing by spot or projection welding.

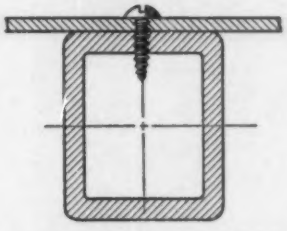


Fig. 2—Self-tapping or drive screws can be used to attach devices to tubing.

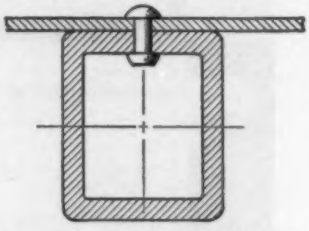


Fig. 3—Blind rivets, mechanical or explosive, can also be used for connection.

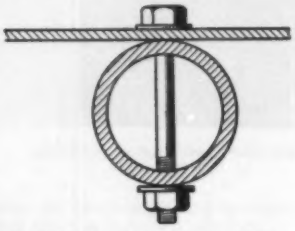


Fig. 4—Bolts or rivets make a rigid connection of plates to tubing.

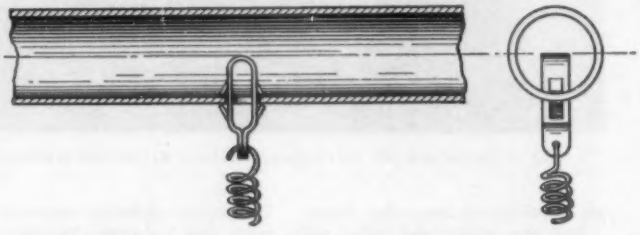


Fig. 5—Clip device is a simple means for holding springs or hangars to tubing. Requires only single hole in tubing and metal prongs lock clip in position.

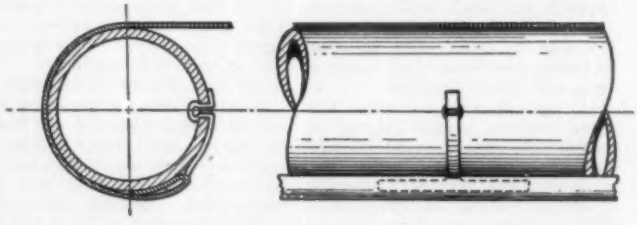


Fig. 6—Fabrics are conveniently fastened to tubing using a metal clip. This clip is inserted into fold of fabric and snapped into hole in tube.

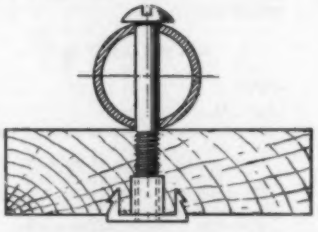


Fig. 7—Wood attachment uses a threaded "T" nut. Prongs hold nut in position.

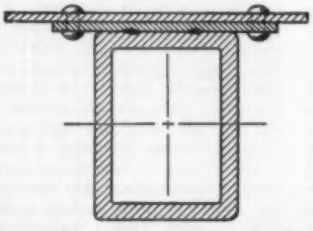


Fig. 8—Fabricated attachment consists of welded strip and riveted joint.

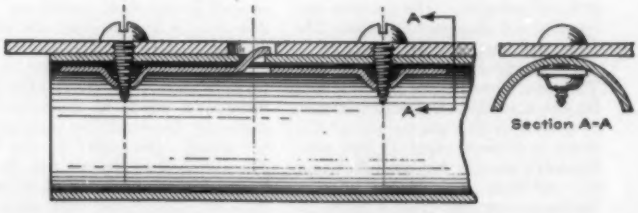


Fig. 9—Threaded clip is held inside tubing by lug and insures a positive connecting device. Clip is used when tubing wall is too thin for screw attachment.

for Attaching Tubing

This construction data has been prepared by the Product Development Committee of the Formed Steel Tube Institute, Cleveland, Ohio.

END FITTINGS

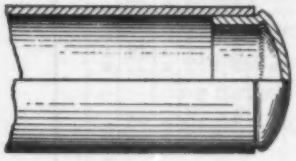


Fig. 10—End plug may be threaded or press-fitted on the OD or ID of tubing.

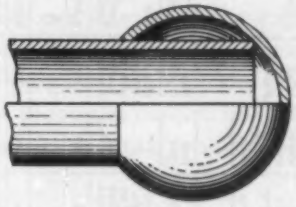


Fig. 11—Ornamental cap may be used to give tubing finished appearance.

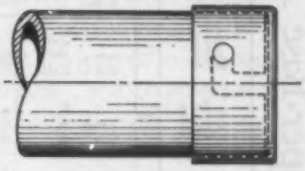


Fig. 12—Detachable cap uses bayonet-type connection for convenient removal.

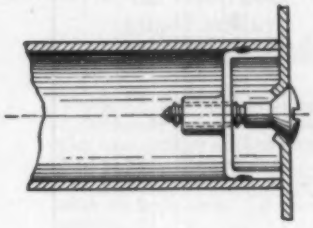


Fig. 13—Threaded insert, welded inside, facilitates the assembly of plates.

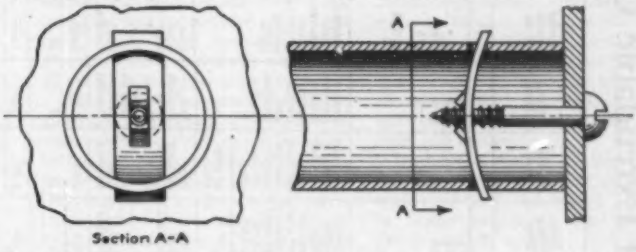


Fig. 14—Spring-steel nut is used for attaching objects to the ends of tubing. Nut requires two slots in the tubing and is held in position by screw.

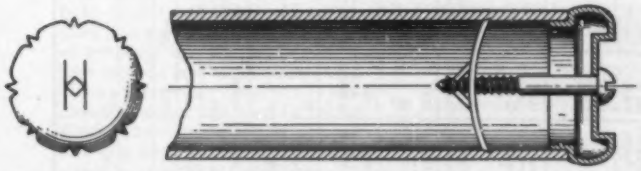


Fig. 15—Arched-nut attachment requires no machining. Nut is first rammed into tube; tightening of screw forces barbs into metal for positive anchorage.

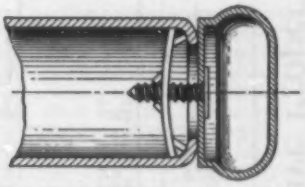


Fig. 16—Rolled-end of tubing simplifies attachment of end fitting.

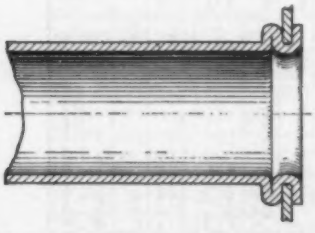


Fig. 17—Roll and press operation can be used to firmly hold tubing in plate.

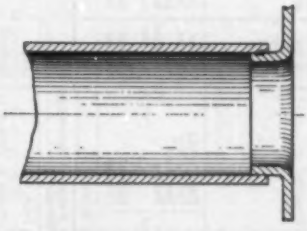


Fig. 18—Formed plate facilitates attachment of tubing by welding or brazing.

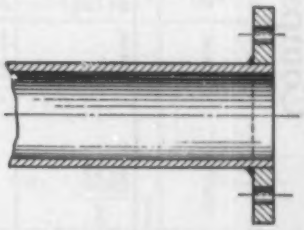


Fig. 19—Flange fitting for piping is made by welding flange to tubing.

Comparative Properties of Extrudable Copper-Base Alloys

Alloy Name	Copper	Free-Cutting Copper	Leaded Commercial Bronze	Medium-Leaded Brass	Special Low-Leaded Brass	Riveting and Turning Rod	Free-Cutting Brass	Forging Brass	Muntz Metal	Leaded Naval Brass	Naval Brass	Free Cutting Naval Brass	Manganese Bronze	Architectural Bronze Heavy-Leaded	Architectural Bronze	Arsenical Bronze	13% Nickel Silver
Alloy Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Nominal Composition, percent — Copper	99.90 min.	99.4	80	64.5	62	62	61.5	60.0	60.0	60	60	60	58.5	57	56.5	56.5	42
Zinc	—	—	9.25	35	36.25	36.25	35.5	38.0	40.0	38.5	39.25	37.5	39.2	40	41.25	39	44
Lead	—	—	1.75	0.5	0.75	1.75	3.0	2.0	—	0.75	—	1.75	—	3	2.25	0.75	—
Other		Te 0.6, P 0.007 max.								Sn 0.75	Sn 0.75	Sn 0.75	Fe 1.0, Sn 1.0, Mn 0.2			Ni 2.0, As 0.6, Mn 0.2, Fe 1.0	Ni 13.0
General Properties	High electrical conductivity-high thermal conductivity, excellent working ability.	Similar to copper but with free-cutting properties.	Good bending properties for simple shapes such as drawer handles.	Good bending and forming properties but restricted to simple shapes—good machinability.	Same as medium-leaded brass but with slightly better machinability.	Best compromise between machining & moderate cold-forming properties.	Excellent machinability combined with good mechanical and corrosion resistance properties.	Extremely plastic hot—combining good corrosion resistance with excellent mechanical properties	Inexpensive combination of good strength and moderate ductility	Resistant to salt water corrosion with added machinability	Resistant to salt water corrosion satisfactory for moderate cold-working operations	Similar to free-cutting brass but with increased strength and corrosion resistance	High strength combined with excellent wear resistance	Excellent free machining and forging properties	Excellent forging and machining properties	Excellent forging properties	Silvery white color
Working Properties — Cold Working	Excellent	Good	Good	Good	Fair	Fair	Poor	Fair	Fair	Poor	Fair	Poor	Poor	Very poor	Very poor	Poor	Poor
Hot Working	Excellent	Good	Poor	Poor	Fair	Fair	Good	Excellent	Excellent	Good	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Excellent
Machining	Poor	Excellent	Good*	Good*	Good*	Good*	Excellent*	Good*	Good, carbon arc, metal arc	Good*	Good, carbon arc, metal arc	Excellent*	Good, carbon arc, metal arc	Excellent	Good	Good*	Good
Welding	Decid/ised Type Preferred	Not recommended							Excellent		Excellent		Excellent				Fair
Soldering	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Good	Good		Good		Good		Excellent	Excellent	Excellent	Excellent
Polishing	Excellent	Excellent						Excellent	Excellent		Excellent		Excellent				
Density, lb/cu in.	0.322	0.323	0.319	0.306	0.306	0.306	0.307	0.305	0.303	0.305	0.304	0.305	0.302	0.306	0.305	0.303	0.315
Young's Modulus of Elasticity, psi (000,000 omitted)	17	17	17	15	15	15	14	15	15	15	15	15	15	16	14	16	17
Melting Point, deg F	1,981	1,981	1,900	1,700	1,660	1,650	1,650	1,640	1,660	1,635	1,650	1,650	1,630	1,630	1,633	1,630	—
Avg. Coefficient of Thermal Expansion per deg F (68 to 570 F)	0.0000098	0.0000098	0.0000112	0.0000113	0.0000114	0.0000114	0.0000114	0.0000115	0.0000116	0.0000118	0.0000118	0.0000118	0.0000118	0.0002116	0.0000116	0.0000118	—
Electrical Conductivity % IACS at 68 F	101 (annealed)	90 min.	42 (annealed)	26	27	28	28	27	26	26	26	26	24	28	28	—	—
Thermal Conductivity Btu/sq ft ft/hr F at 68 F	226	205	104	67	69	73	67	69	71	68	67	67	61	71	71	—	—
Tensile Strength, psi	32,000	32,000	37,000	48,000	46,000	50,000	49,000	53,000	54,000	57,000	57,000	57,000	65,000	60,000	60,000	65,000	65,000
Elongation, % in 2 in.	55	40	45	60	55	58	53	45	50	42	47	40	33	30	30	40	20
Yield Strength, 0.5% ext., psi.	10,000	10,000	12,000	12,000	14,000	15,000	18,000	20,000	21,000	19,000	25,000	25,000	30,000	30,000	30,000	22,000	50,000
Rockwell Hardness	40 F	40 F	55 F	56 F	60 F	67 F	68 F	78 F	80 F	82 F	55 B	55 B	65 B	65 B	65 B	55 B	93 B
Forging Temp., F	1,400–1,600						1,300–1,450	1,200–1,500	1,150–1,450	1,200–1,400	1,200–1,450	1,200–1,400	1,150–1,450	1,150–1,350	1,150–1,350	1,200–1,450	1,150–1,650
ASTM Specifications	B124		B140					B124	B124		B21, B124	B21	B124, B138				

*Non-leaded alloys preferred for welding.

How to Use Extrusions Of Copper and Its Alloys

Copper-base alloys can be extruded in a wide variety of shapes and sizes to make an almost limitless range of products with the addition of low-cost machining operations. Applications of copper alloy extrusions depend on material used, properties desired, volume produced, and complexity of shape. Case histories of actual products bring out design characteristics.

R. CARSON DALZELL
Chief Technical Advisor

D. C. FINLEY
Product Engineer, Extruded Shapes
Revere Copper and Brass Incorporated

WHERE A LARGE VOLUME is needed of dimensionally accurate parts, with complex cross-section, uniform properties, good surface, freedom from porosity, and good machinability, extrusion is often the only economical production method.

Extrusion is fundamentally one of the simplest of brass mill operations. A cast solid metal cylinder, the billet, is heated to a temperature from about 1,200 F to 2,000 F. This is placed in a pre-heated container and pressures from 35,000 to 140,000 psi are applied, forcing the metal through a die of the shape desired. Total loads as high as 7,500 tons are sometimes used. These pressures and temperatures limit extrusion shapes and sizes in various alloys. Research on metals for hot-extrusion dies and die-design improvements are widening these limits.

Brass extrusions are sometimes given one or two cold sizing or shaping draws, through other dies, to meet close dimensional tolerances or to form a shape that cannot be extruded to the finished form. With copper extrusions this is also done to improve the surface and stiffness of the shape.

Extrusions are cut to specified length before shipment, ranging from fractions of an inch to twenty feet or more. These are ready for forging, drilling or other machining, as well as polishing and finishing operations.

Copper-brass alloy extrusions have important advantages. Color is often a deciding factor, favoring these alloys when the finished article is to be sold without plating. Of all the metals, only gold and copper-base alloys have color. Red, gold, bronze, yellow, greenish yellow, and tinted whites are all available in copper alloy extrusions.

If parts are to be plated, the copper alloys are unsurpassed, as adhesion of electroplates to these metals is excellent. In some decorative electroplates, where it is anticipated that the plate will wear off, it is common practice to select a nickel silver extrusion to avoid color contrast. Other decorative effects are obtained with extrusions of contrasting color, by polishing the plate off the high spots to develop a pattern.

Copper-base metals form a slight tarnish film indoors, or an attractive patina outdoors. Copper and its alloys have tarnish resistance superior to that of silver when exposed to home and industrial atmospheres. Aluminum is the only commercially extruded metal which is less affected.

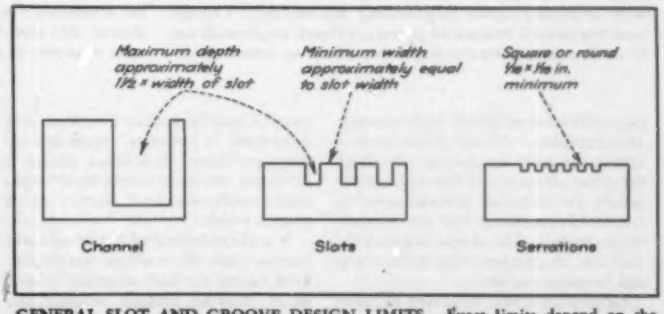
The extrudable brasses, bronzes, and nickel silvers have inherently good machining properties. The metallurgist refers to them as having a duplex or alpha-beta crystalline structure, characteristically machining with small brittle chips. A great many of the extrudable alloys have lead incorporated to enhance the machining and drilling properties still further.

In common with all of the copper-base alloys, the extruded alloys are readily soldered and brazed. Joining by fusion welding is also possible, though seldom justified. If it is considered necessary, one of the non-leaded alloys should be used.

Properties

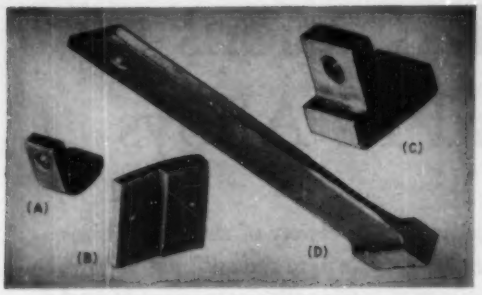
Composition and approximate physical and mechanical properties of copper and the copper-base alloys commonly extruded with irregular cross-sections are shown in Table I. Other alloys extruded only in very simple shapes, will not be discussed.

The alloys listed in the table on

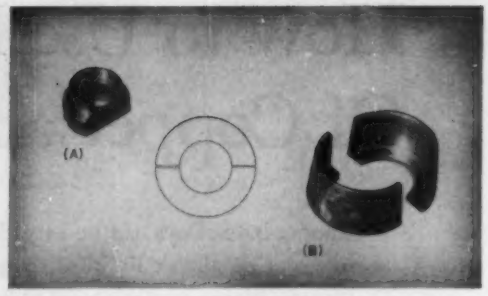

Maximum depth approximately 1½ × width of slot
Minimum width approximately equal to slot width
Square or round ⅛ × ⅛ in. minimum
Channel
Slots
Serrations

GENERAL SLOT AND GROOVE DESIGN LIMITS. Exact limits depend on the alloy selected and tolerances required in the finished part.

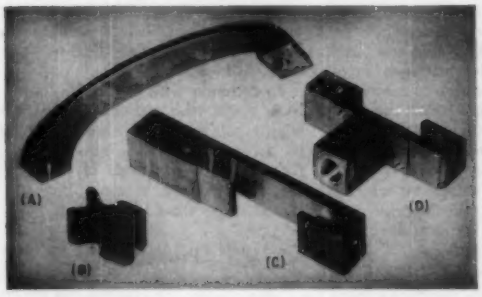
Extrusion Applications Demonstrate Practical Design Principles



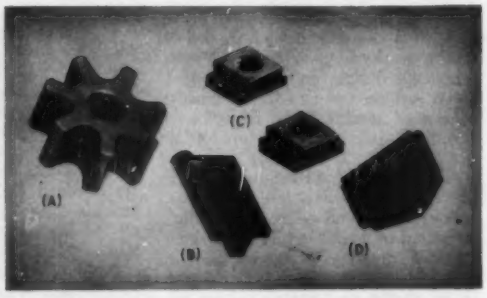
1 These parts are made of copper because they are current-conducting elements in electrical apparatus. Since practically no machining is required, the extra cost of tellurium copper is unnecessary. Parts A, B and C could be made by casting, powder metallurgy, forging, or machining from bar stock. Comparison of finished parts and all secondary operations indicated a substantial cost saving for extruded shapes, which are merely cut to required length, and holes are drilled. Part D is an exception to the minimum thickness rule. It is 4½ in. long, with most of the section thickness ⅛ in. Square copper bar with milled slot was fitted in and silver soldered to thinner copper strip.



2 Part A was formerly made from round free-cutting brass rod. After the automatic screw machine operations, a flat was milled to a depth of ¼ in. By feeding a round shape with the desired flat surface into the screw machines, the milling operation was eliminated. In B, a flexible hose connection consisting of two halves was required to be non-rusting, strong and hard. Powder compacting was a possibility but walls are thin. It could not be made from rod or tube; the saw kerf would not allow two complete semicircles to remain. A simple and cheap solution consisted of using the semicircular shape shown in No. 4 alloy. Two of these together were fed into a screw machine.



5 The drawer pull shown as A is an example of combining artistic design with the potentialities of extrusion. A saw cut off every ½ in. gives a carefully shaped handle. The pieces are then drilled and tapped, tumbled and polished. Part B, an overhead crane trolley section, is another example of a part that can be produced economically only by extrusion. The The bellows diaphragm connection fitting shown as C and D must be very rigid and pressure tight, and must be of an alloy permitting rather deep drilling and tapping. Castings were not suitable because of porosity. Heavy strips could not be bent to sharp corners and assembly would be expensive.



6 Even the drawing operation will not provide the unusually close tolerance required on the teeth of the oil pump pinion (A), so this shape is pushed through a shaving die. The finishing operations consist of cutting off, drilling and reaming. The saving over precise gear cutting is great. Alloy No. 8 is used for strength and hardness combined with good machinability. Brass is required because these pinions rub against steel. Brass would be used even if the bearing problem were not considered, since the low cost of extrusion makes brass cheaper than steel in such a part. Samples B, C and D are other examples of eliminating longitudinal machining.

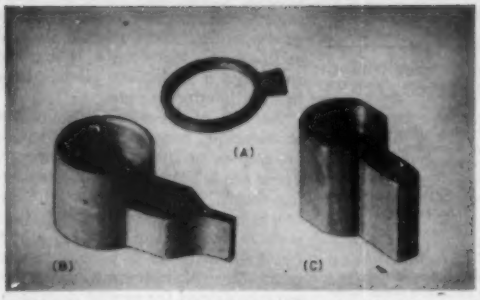
page 108 have relatively high strength and hardness. All of them have a dense, fine-grain structure as a result of the great pressure and thorough working in the extrusion process, assuring freedom from defects that are common in cast metals. The shapes are smooth, uniform in cross-section, with sharp and accurate profiles.

General corrosion resistance of these extrudable alloys, as of all copper-base alloys, is excellent. Tabulating resistance to specific media, however, it is considered a practical approach to these problems. Individual corrosion problems must be considered separately, with associated factors given proper weight.

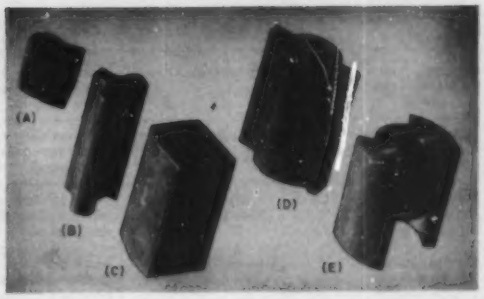
It is characteristic of the brasses and bronzes that those alloys which hot-work easiest are least amenable to cold work. Bending, peening, swaging, and the like should be kept at a minimum. If the alloy is leaded, this limitation cannot be overcome by local heating.

Design possibilities offered by extruded shapes are many. If a part has a constant cross-section it can probably be made from an extrusion. There are limitations which will be discussed later, but even some of these can be avoided by applying secondary operations. If these secondary operations are not expensive, the net result can be superior to any other process.

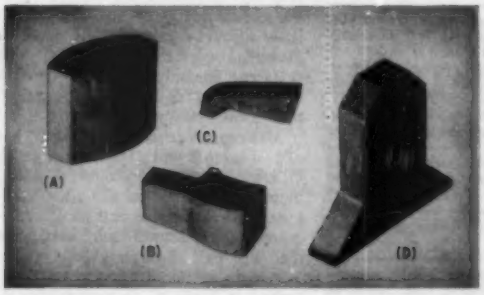
The cheapest way to produce ex-



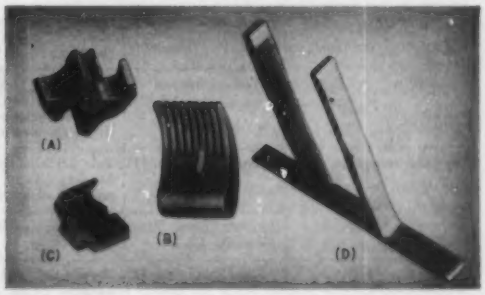
3 These parts have substantial projections, but like 2B, should be put into automatic screw machines for high volume, low cost production. By extruding a solid section, the exact profile is obtained, located precisely in the correct relationship to the ring section. The solid section is then fed into an automatic screw machine to complete the part. Parts A and B are made of alloy No. 15. In addition to good machinability, A requires high strength. Part B was made from this alloy instead of alloy 7 because the thin part of the projection cannot be extruded in alloy 7. Part C, part of a cylinder lock, is made of alloy No. 7 for low metal cost, better deep drilling quality.



4 Part A is another example of an extruded shape making a simple screw machine job of an otherwise difficult part. Use of extruded design in parts B and C completely eliminate machining and surface broaching. The tiny slot in C illustrates the minimum size that can be extruded, about 1/16 in. square, and it is also as close to the edge as possible. The trumpet valve stock (D) is a precision job requiring only a cutoff and a machine finish operation. Another bad combination of longitudinal and circumferential machining was represented by the former design of part E. As a solid extruded shape the slow lengthwise machining operation is eliminated.



7 The padlock body, A, replaces a casting. Cutting-to-length, drilling, and polishing operations finish it. There is no possibility of internal porosity to cause rejects. Strength is high, cost low, and appearance excellent. Another simple cut-off job is shown in B, a seat facing for valves, which is locked into castings by hammering into place. Close tolerances are required, and the metal must be dead soft. Because of these conditions Alloy No. 8 is used, though it is not usually recommended for peening. Bathroom fixtures that are examples of low cost attractive design are shown in Parts C and D. Design from extruded sections is "natural" in parts of this type.



8 It is difficult to conceive of A, B and C being manufactured any way except by using extruded sections. The intricate continuous and discontinuous curves would be prohibitive to duplicate in quantity by machining methods. They offer no great problems as brass extrusions. A similar part is a hinge assembly that has been manufactured for years by using extruded sections. The heavy brass hinge smacks of good quality, yet production cost is low. The extruded sections are cut to length, milled, drilled, and the pins sweated in. Part D replaces a casting on which the polishing and plating were too costly. Alloy No. 15 is used to facilitate extruding the long thin sections.

tremely small quanties is to machine from bar stock by hand feed. Designing and making a pattern for sand casting might or might not cost as much as an extrusion die, depending on complexity. Extrusion-die costs for simple shapes start at about sixty dollars. Brass mills extrude from a billet weighing 50 lb or more, and expect the buyer to order at least the product of one billet as a trial lot.

Since a machined section is comparable in almost every physical respect with an extrusion in the same alloy, the practical approach is to use a handmade part in the early stages of design. From these, dimensions and tolerances can be developed in consultation with brass mill engineer.

The decision must then be made as to which alloy is desired for the trial extrusion run. Possibly it is desirable to have the extrusion match the color of another part made from a brass rod, strip or tube. In addition, one of the properties listed in the first column of Table II might be considered important. Usually these narrow the choice down to a few of the available alloys. Then the last column of Table I is considered, in conjunction with prices and other requirements.

Minimum thicknesses indicated as available in Table I are for small shapes. If the shape can pass through a 2 in. circle, the minimum gage can

Table I—Selection of Extrudable Copper-Base Alloys

Desired Characteristic	Alloy Name and No. (see table on page 108)	Comments
Highest electrical and thermal conductivity	Copper (No. 1)	Machinability poor. Excellent bending, peening. Average minimum thickness about 0.125 in.
Over 90% conductivity plus machinability	Free-cutting Copper (No. 2)	Machinability very good. Bending good. Moderate peening, swaging. Average minimum thickness about 0.125 in.
Good bending and flaring	Leaded Brass (Nos. 4, 5, 6)	Machinability good. Sections must be relatively simple. Desirable minimum thickness about 0.187 in.
Good punching	Muntz Metal (No. 9)	Moderate bends. Excellent brazing. Machinability good. Fairly simple sections and minimum thickness about 0.187 in. desirable.
Excellent machinability	Free-cutting Brass (No. 7)	Good strength. Slight bending or peening if dead soft. No restriction of sections but minimum average thickness about 0.125 in. desirable.
	Architectural Bronze (Nos. 14, 15)	Good strength. No bending, peening. No restrictions on sections. Minimum thickness about 0.062 in.
Hot forging	Forging Brass (No. 8)	Strong and hard. Good machinability. Large radius bending permissible. Any sections obtainable with minimum thickness about 0.125 in.
High strength	Manganese Bronze (No. 13)	Good wear resistance. Fair machinability. Simple sections with minimum thickness about 0.187 in.
	Arsenical Bronze (No. 16)	Good wear resistance. Good bearing properties, particularly at low speeds. Excellent machinability. Simple sections with minimum thickness about 0.187 in.
Corrosion resistance	Naval Brass (No. 11)	Fair machinability. Little to moderate bending. Good strength. All sections possible with min. thick. about 0.125 in.
	Leaded Naval Brass (Nos. 10, 12)	Good machinability. Otherwise same as Naval Brass.
White color	Nickel Silver (No. 17)	Very hard and strong. Fair machinability. Some bending. All types of sections to about 0.187 in. minimum.

Table II—Standard Tolerances for Extruded Shapes

Dimensions, in.	Manganese Bronze and Nickel Silver Plain Extruded	Brass and Architectural Bronze Plain Extruded	Copper and Leaded Brass Extruded and Drawn
	Tolerances, in., plus and minus		
0.000–0.125	0.010	0.005	0.003
0.126–0.500	0.015	0.005	0.003
0.501–1.000	0.020	0.0075	0.005
1.001–2.000	0.025	0.010	0.0075
2.001–3.000	0.030	0.015	0.010
3.001–4.000	0.035	0.020	0.015
4.001–5.000	0.045	0.030	0.020
5.001 and over	0.060	0.035	0.030

be produced. Larger shapes must have correspondingly heavier minimum gages, with the largest extrusions, those passing through an 8½ in. circle, requiring about 0.250 in. minimum thickness.

Fundamentally any part can be produced economically as an extruded shape if the "bounding surface" is parallel to the extrusion axis. This means that the shape must have a constant cross-section throughout its length and that any holes, slots or grooves not parallel to the longitudinal axis can be produced only by piercing, drilling or other subsequent machining operations. Also, the shape must be solid; hollow shape extrusions in copper-bass alloys are not practical at this time. However, it is practical to design a multipiece closed shape held by interlocking lugs.

Because of die-strength limitations at extrusion temperature, restrictions on grooves or channels are necessary. These are indicated in the accompanying sketch. For a deep channel adjacent to a thin leg on an outside surface, such as the lefthand drawing, a special mill operation is necessary. The possibilities of such constructions are too complicated for general discussion.

A radius of 0.010 in. is considered a sharp corner. It is preferable to design for 1/64 in. or even 1/32 in. radii at corners if possible.

Surface quality should be given careful consideration. Extrusions, particularly if drawn after extrusion, have good surface finish; thus, polishing costs will be at a minimum. However, scratches and nicks will occur to some extent, if straightness is a requirement. It is not considered practical to define the surface quality of extruded copper-base alloys by micro-inches or other methods used for machined or ground surfaces. The only satisfactory description found so far is by submitting samples to the brass mill engineer.

Maximum size varies somewhat, but extrusions that will pass through an 8½ in. circle are widely obtainable. Minimum size depends on the alloy, complexity of the shape, and accuracy required. Some shapes have been made that will pass through a ¼ in. circle. Minimum section thicknesses are described in Table II. In copper-base alloys, with an extrude pushing through an 8½ in. circle, for best physical and mechanical properties, cross-sectional area of the shape should not exceed about 6 or 7 sq in. For heavier sections it is often possible to design two or more interlocking shapes to form one large one.

Standard tolerances are listed in Table II. On part drawings critical dimensions and tolerances should be shown in decimal fractions; noncritical dimensions should be shown in either decimals or without tolerance requirements. If a tolerance closer than standard is essential, it should be indicated; however, tolerances looser than standard should be specified as well. The "exposed surface" should be indicated, signifying that best surface quality is required only on this area. The designer who avoids unnecessarily tight specifications will be rewarded with minimum die-charge and cost per pound for the metal.

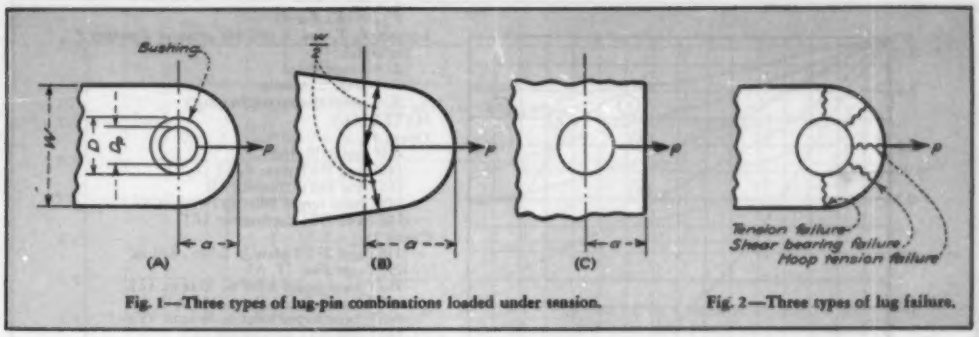


Fig. 1—Three types of lug-pin combinations loaded under tension.

Fig. 2—Three types of lug failure.

Analysis of Lugs And Shear Pins Made of Aluminum Or Steel Alloys

Method of analysis and procedure for the design of lug-pin combinations made of aluminum or steel alloys. Constructions analyzed include lugs of irregular section and lug-pin combination assemblies having multiple shear connections.

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Lockheed Aircraft Corporation

EXAMINATION OF MANY TEST RESULTS on lugs of different materials and geometries led to the conclusion that existing conventional methods of stress analysis of lug-pin combinations were conservative in some respects and rather seriously unconservative in others. It seemed desirable, therefore, to thoroughly overhaul the existing methods of lug analysis.

The procedure for lug analysis that resulted from this investigation is presented in the following discussion. It is based largely upon theory, but the validity of the methods has been verified by comparison with many tests.

This procedure is applicable only to steel or aluminum alloy lugs of uniform thickness, Fig. 1, under tension.

OUTLINE OF METHOD. In analyzing any lug-pin combination, all possible ways in which failure can occur, some of which are shown in Fig. 2, must be considered. These are:

1. Tension across the net section. Because of stress concentration, the full P/A stress cannot be carried. Failure to take account of this stress concentration can result in seriously unconservative design.

2. Shear tear-out or bearing. These two types of failure are closely related and are covered by a single calculation based upon empirical curves. Previous methods based upon an arbitrary shear stress calculation have been excessively conservative.

3. Hoop tension at tip of lug. No separate calculation need be made, as the shear-bearing allowables also account for the possibility of hoop tension failure.

4. Shearing of the pin. Conventional methods are satisfactory.

5. Bending of the pin. The load on the pin is assumed to be uniformly distributed along the pin and the ultimate strength of the pin is based on modulus of rupture. This assumption may be somewhat conservative, but to ignore pin bending completely can be very unconservative. Pin bending is easy to overlook as a cause of failure because pins seldom break; instead, bending of the pin concentrates load at the edges of the lug and causes the actual fracture to occur in the lug.

6. Excessive yielding of the bushing, if a bushing is used. Yielding of the lug is considered to be excessive at a permanent set 0.02 times the pin diameter. Yielding of the lug must always be checked, as it frequently occurs at a lower load than would be anticipated from the ratio of tensile yield stress F_{ty} to ultimate tensile strength F_{tu} of the lug material.

Yielding of the pin, and ultimate strength of the bushing are never critical in aircraft practice where applied yield loads are between 0.67 (1/1.50) and 0.77 (1.15/1.50) of the applied ultimate loads.

FACTORS OF SAFETY. The proper choice of factors of safety is beyond the scope of this discussion. It is suggested, however, that lugs be designed conservatively, as their weight is usu-

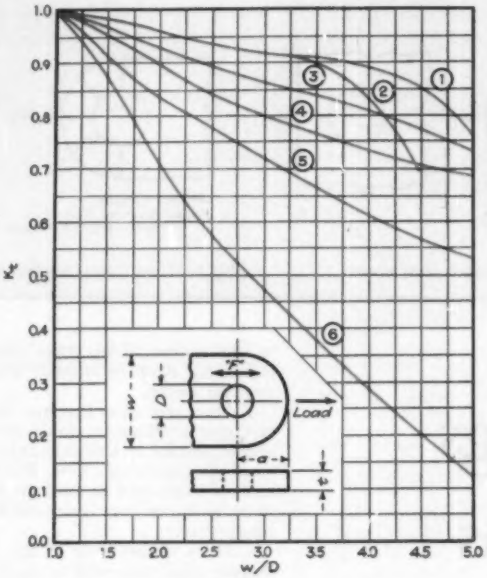

Fig. 3—Values of tension efficiency factors of lugs.

$P'_{tu} = K_t F_{tu} A_t$

LEGEND. L, T, and N indicate grain in direction F in sketch:
L = longitudinal
T = long transverse
N = short transverse (normal)

MATERIALS

CURVE 1:
4130 and 8630 steel
14ST and 75ST plate ≤ 0.5 (L, T)
75ST bar and extrusion (L)
14ST hand forged billet ≤ 144 sq in. (L)
14ST and 75ST die forgings (L)

CURVE 2:
14ST and 75 ST plate > 0.5 in., ≤ 1 in.
75ST extrusion (T, N)
75ST hand forged billet ≤ 36 sq in. (L)
14ST hand forged billet > 144 sq in. (L)
14ST hand forged billet ≤ 36 sq in. (T)
14ST and 75ST die forgings (T)

CURVE 3:
24ST80 plate (L, T)
24ST extrusion (L, T, N)

CURVE 4:
24ST0 plate (L, T)
24ST1 plate (L, T)
14ST and 75ST plate $>$ 1 in. (L, T)
24ST bar (L, T)
75ST hand forged billet $>$ 36 sq in. (L)
75ST hand forged billet $\leq$ 16 sq in. (T)

CURVE 5:
195T6, 220T4, and 356T6 aluminum alloy casting
75ST hand forged billet $>$ 16 sq in. (T)
14ST hand forged billet $>$ 36 sq in. (T)

CURVE 6:
Aluminum alloy plate, bar, hand forged billet, and die forging (N)
NOTE: for die forging, N direction exists only at parting plane.
75ST bar (T)

ally small relative to their importance, and inaccuracies in manufacture are difficult to control. An additional factor of safety (over and above whatever fitting or casting factor is required by applicable specifications) of about 1.20 is considered appropriate. In addition, it is good practice to provide sufficient material to permit drilling out the hole for a bushing, if such is not already included in the original design.

Notation and Nomenclature

In addition to the letter symbols indicated in Fig. 1, the following notation is used:

- t = thickness of lug
- F_{tu} = ultimate tensile strength of lug material
- F_{tuw} = ultimate tensile strength of lug material with grain
- F_{tus} = ultimate tensile strength of lug material cross grain
- F_{ty} = tensile yield stress of lug material
- F_{tyw} = tensile yield stress of lug material with grain
- F_{tys} = tensile yield stress of lug material cross grain
- F_{cy} = compressive yield stress of bushing material
- P_l = applied limit load
- P_u = applied ultimate load, this value is usually 1.5 P_l
- P_y = applied yield load: Air Force and CAA equals P_l, Navy equals 1.15 P_l
- M = applied bending moment on pin
- P'_u = allowable ultimate load
- P'_{tu} = allowable ultimate load as determined by tension
- P'_{bru} = allowable ultimate load as determined by shear-bearing
- P'_y = allowable yield load on lug
- P'_{bry} = allowable yield bearing load on bushing
- A_{br} = projected bearing area
- A_t = minimum net section area for tension
- K_t = efficiency factor for tension
- K_{br} = efficiency factor for shear-bearing
- C = yield factor

Analysis Procedure

The following outlined procedure gives the allowable load for each possible way in which the lug-pin combination may fail. Adequacy of the part is then determined by comparing each of these allowable loads (yield or ultimate) with the corresponding applied load by means of the conventional margin of safety calculation.

GIVEN. Applied ultimate load P_u and applied yield load P_y; required fitting and casting factors; pin and lug material; and as designated in Fig. 1, the dimensions a, w, D, D_p, and thickness t of lug.

1. Preliminary Calculations. Compute w/D, a/D, D/t,

$$A_{br} = Dt, \text{ and } A_t = (w - D)t$$

2. Tension Across the Net Section. Enter Fig. 3 with w/D and obtain K_t for the proper material. Obtain allowable ultimate load P'_{tu} for tension failure:

$$P'_{tu} = K_t F_{tu} A_t$$

The efficiency factor K_t given by Fig. 3 is simply the reciprocal of an effective plastic stress concentration factor at ultimate load. Values of K_t were obtained using typical stress-strain curves for the various materials, together with the appropriate elastic stress concentration factors to which a semi-rational correction factor had been applied.

3. Shear-Bearing. Enter Fig. 4 with a/D and D/t and obtain K_{br}. Obtain allowable ultimate load P'_{bru} for shear-bearing failure:

$$P'_{bru} = K_{br} A_{br} F_{tus}$$

4. Lug Yield. Take the smaller of P'_{tu} and P'_{bru} as P'_{umin}. Enter Fig. 5 with P'_{umin}/A_{br}, F_{tus} and obtain C. Obtain the allowable yield load for the lug.

$$P'_y = C \frac{F_{tys}}{F_{tus}} P'_{umin}$$

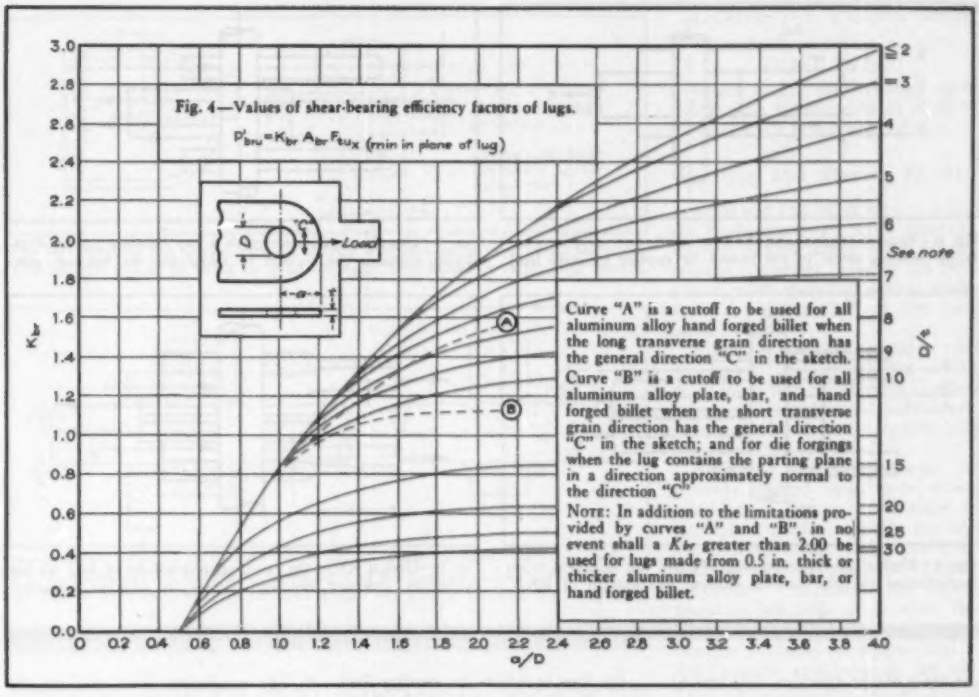
Fig. 4—Values of shear-bearing efficiency factors of lugs.
$P'_{bru} = K_{br} A_{br} F_{tu_x}$ (min in plane of lug)
Load
Curve "A" is a cutoff to be used for all aluminum alloy hand forged billet when the long transverse grain direction has the general direction "C" in the sketch.
Curve "B" is a cutoff to be used for all aluminum alloy plate, bar, and hand forged billet when the short transverse grain direction has the general direction "C" in the sketch; and for die forgings when the lug contains the parting plane in a direction approximately normal to the direction "C"
Note: In addition to the limitations provided by curves "A" and "B", in no event shall a K_{br} greater than 2.00 be used for lugs made from 0.5 in. thick or thicker aluminum alloy plate, bar, or hand forged billet.
K_{br}
a/D
D/e
See note

5. Bushing Yield. Take A_{brb} as the smaller of the bearing areas of bushing on pin or bushing on lug. (The latter may be smaller as a result of external chamfer of the bushing.) Obtain allowable yield bearing load on bushing P'_{bry}:

$$P'_{bry} = 1.85\, F_{ty}\, A_{brb}$$

6. Pin Shear. Check pin shear in the usual manner.

7. Pin Bending. For the construction shown in Fig. 6, calculate bending stress in the pin resulting from the applied ultimate load P_u, assuming My/I bending stress distribution and maximum bending moment as given by:

$$M = \frac{P_u}{8}(2t_1 + t_2)$$

This formula for bending moment follows from the assumption of uniform bearing stress distribution across each of the three lugs. This assumption may be conservative in some designs and constructions by as much as 30 percent.

Obtain modulus of rupture of pin from ANC5a or other authoritative source. For a solid round pin of any material having a tensile yield stress F_{ty} at least 75 percent of the ultimate tensile strength F_{tu} and an ultimate elongation of at least 10 percent, the modulus of rupture will be between 1.60 and 1.68 times the ultimate tensile strength.

If there is a gap between mating lugs, as shown in Fig. 7, the pin bending analysis is the same except for the equation giving pin bending moment. In this event, the moment arm b is measured as indicated in Fig. 7, the loads $P_u/2$ being assumed uniformly distributed, and the moment is then given by:

$$M = \frac{P_u b}{2}$$

If either of the foregoing analyses should show inadequate pin bending strength but an excess of strength in the lug, it may be possible to take advantage of the excess lug strength to show adequate strength of pin, by the following procedure:

A. Consider the pin loads to be uniformly distributed over a reduced lug thickness as shown in Fig. 8, where the cross-section area becomes inactive. This redistribution takes place because as the pin begins to bend, the bearing load on the lugs tends to concentrate near the shear planes leaving some of the lug material inactive. The distribution over the reduced thickness tends to remain uniform, however, because of the plastic behavior of the lug. The value of effective thickness to be used in the analysis may have any desired value and should be chosen by trial and error to give approximately equal margins of safety for pin and lugs.

B. Recalculate all lug margins of safety with allowable loads reduced in

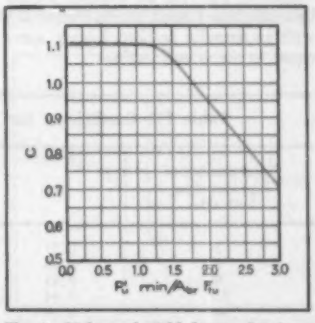

Fig. 5—Values of yield factors for lugs.

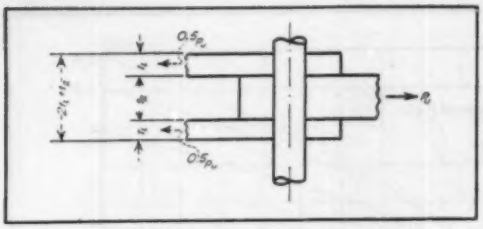

Fig. 6—Lug-pin combination showing dimensions used in calculating bending stress in pin caused by applied ultimate load.

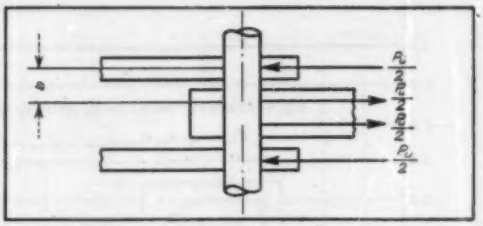

Fig. 7—Lug-pin combination with a gap between mating lugs. Sketch indicates the method of measuring the moment arm.

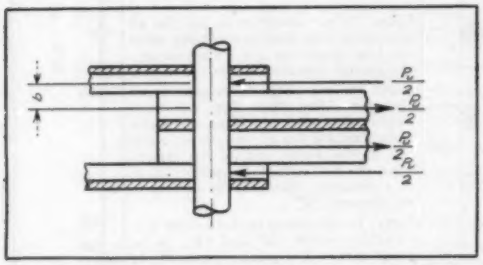

Fig. 8—Method of approximating effective lug thickness when recalculating the pin bending moment and margin of safety.

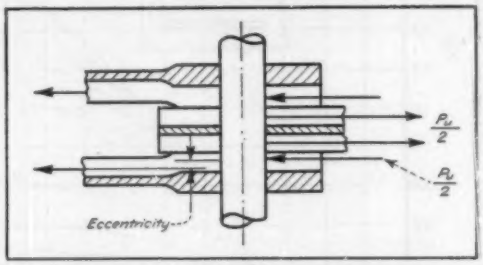

Fig. 9—Design where the resulting eccentricity of load on lug introduces excessive bending stresses in adjacent structure.

the ratio of the effective thickness to the actual thickness of the lugs.

C. Recalculate pin bending moment, M equals $P_u b/2$, and margin of safety using a reduced value of b as indicated in Fig. 8. Care should be taken not to reduce b as described in Paragraph (A) if the resulting eccentricity of load on the lug introduces excessive bending stresses in the adjacent structure, as shown in Fig. 9. In such designs, the pin must be strong enough to distribute the load uniformly across the entire lug.

LUGS OF IRREGULAR SECTION. For lugs of irregular section having the bearing load distributed over the entire thickness, Fig. 10, an analysis should be made based upon an equivalent lug with rectangular sections having areas equal to the actual sections.

For lugs in which the bearing load is not distributed over the entire thickness, Fig. 11, no definite rules can be given; however, the general methods given in this article may be adapted to such designs.

MULTIPLE SHEAR AND SINGLE SHEAR CONNECTIONS. Lug-pin combinations having the geometry indicated in Fig. 12 should be analyzed according to the following criteria:

A. The load carried by each lug shall be determined by distributing the total applied load p among the lugs as indicated in Fig. 12, β being obtained from Table I.

This distribution is based on the assumption of plastic behavior (at ultimate load) of the lugs and elastic bending of the pin, and gives approximately zero bending deflection of pin.

B. The maximum shear load on the pin is then given in Table I.

C. The maximum bending moment in the pin is given by the formula: where b is given in Table I,

$$M = p' b/2$$

Single shear connections, Fig. 13, should be avoided wherever possible because of the high degree of uncertainty in their analysis, which results chiefly from the unknown clamping effect of the bolt head and nut and relative stiffness of the attaching members.

Table I — Coefficients for Multiple Shear Connections

Total number of lugs including both sides	β	Pin Shear, lb	b
5	0.35	0.50 p'	0.28 $(t' + t'')/2$
7	0.40	0.53 p'	0.33 $(t' + t'')/2$
9	0.43	0.54 p'	0.37 $(t' + t'')/2$
11	0.44	0.54 p'	0.39 $(t' + t'')/2$
∞	0.50	0.50 p'	0.50 $(t' + t'')/2$

Allowable Bearing Stress

The concept that shear-tearout and bearing failures are essentially the same phenomenon can be used to advantage to determine allowable bearing stresses for alloys for which no published bearing allowables are available or for ranges of a/D and D/t for which available values do not apply.

The allowable load for shear-bearing failure of a lug was given previously as:

$$P'_{bru} = K_{br} A_{br} F_{tuo}$$

Dividing both sides of this equation by A_{br} gives the allowable bearing stress:

$$F_{bru} = K_{br} F_{tuo}$$

The allowable bearing stress can be

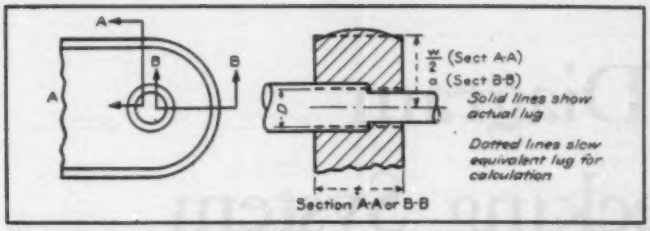

Fig. 10—Irregular lug section with the bearing load distributed over entire thickness. This analysis should be based on a lug of equal area having a rectangular section.

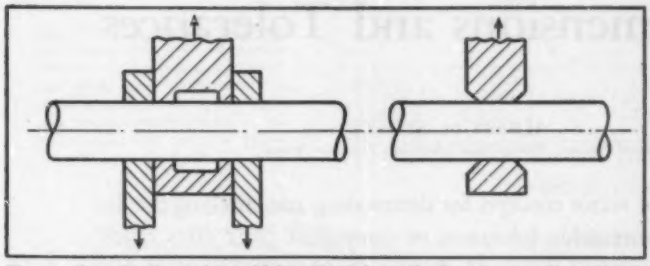

Fig. 11—Irregular lug sections with bearing load not distributed over entire thickness. No definite analysis rules apply for such designs but general methods can be adapted.

obtained from this formula for any aluminum or steel alloy and for any value of a/D and D/t, using the values of K_{br} given by the curves of Fig. 4. The bearing allowables thus obtained apply to holes near the edge of flat sheet, Fig. 1 (C), as well as to lugs, Figs. 1 (A) and (B).

In ANC-5a allowable bearing stress is given only for a/D equal to 1.5 and 2.0, and only for D/t less than 5.5. The ANC-5a bearing allowables for a/D equal to 1.5 and 2.0 are in close agreement with Fig. 4. For values of a/D between 1.5 and 2.0, ANC-5a specifies linear interpolation, which likewise is in good agreement with Fig. 4. For a/D greater than 2.0, ANC-5a calls for the use of the value for a/D equal to 2.0, which is seen from Fig. 4 to be conservative.

The wide variation in K_{br} to be seen in Fig. 4 emphasizes the fact that allowable bearing stress depends upon the geometry of the application and therefore is not a fixed property of the material like ultimate tensile strength or tensile yield stress.

Yield allowable bearing stress likewise can readily be determined, in the following manner:

1. Obtain K_{br} from Fig. 4.
2. Enter Fig. 5 with

$$\frac{P'_{max}}{A_{br} F_{tuo}} = K_{br} \text{ and obtain } C$$

3. Obtain yield allowable bearing stress:

$$F_{bry} = C\ K_{br} F_{tyo}$$

Values of F_{bry} thus obtained agree closely with values given in ANC-5a for a/D equal to 1.5 and 2.0.

Bearings and Bearing Factors

A bearing may be defined as a lug-pin combination—or, more generally, any pin-jointed fitting—that permits relative movement between the parts joined other than that which results from the deformation of the parts under load.

Allowable bearing pressures for bearings as thus defined are usually much lower than the allowable bearing pressures obtained by the methods previously discussed, which consider only static strength.

Allowable bearing pressures for bearings depend upon such service conditions as frequency and extent of the relative motion, whether the relative motion occurs under maximum load, and whether shock or vibration are present. It is believed that the lug geometry has little effect upon this allowable, but that for unlubricated bearings it should be proportional to the hardness, and hence to the ultimate tensile strength, of the lug or bushing material.

Therefore if such an allowable is obtained by means of "bearing factors" such as given in ANC-5a, the basic allowable to which the factors are applied should not be the bearing allowable used in the static-strength analysis, but should instead be obtained from Fig. 4 or some particular a/D, say a/D equal to 1.50, which would be used for all lugs regardless of the actual a/D.

This check of the lug as a bearing should be made in addition to, rather than in place of, the static-strength analysis, since if a/D is very small the static strength may be more critical.

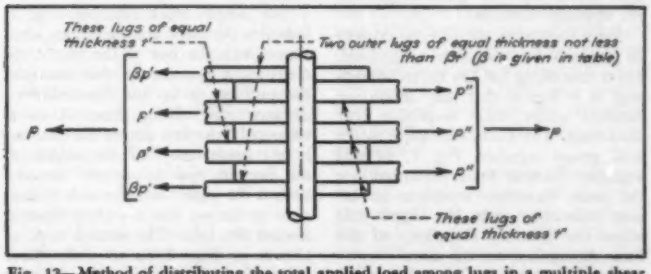
These lugs of equal thickness t'
Two outer lugs of equal thickness not less than βt' (β is given in table)
βp'
p'
p''
P
P
These lugs of equal thickness t''

Fig. 12—Method of distributing the total applied load among lugs in a multiple shear connection on the assumption of plastic behavior of lugs and elastic bending of pin.

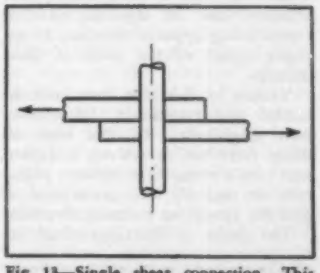

Fig. 13—Single shear connection. This design should be avoided when possible.

Vector Diagram Checking System

For Dimensions and Tolerances

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Method based on vector concepts for determining and checking the dimensions and permissible tolerances of component parts saves much time and labor, computations and chances of error are fewer. Versatility of the method is demonstrated with problems met with in dimensioning single and multiple pin jointed members under tension, compression and alternating loads, and in a telescoping assembly of tubes.

IN WORKING WITH DIMENSIONS having bilateral tolerances, most checking systems require individual treatment of each tolerance to obtain maximum and minimum values, and then a selection of the proper value for each calculation. Many superfluous answers are obtained before the desired result is reached.

The use of a vector system, based on a method developed by C. Walton Musser, has yielded excellent results in the mechanical engineering design section of the Pitman-Dunn Laboratory at Frankford Arsenal.

For the most part, this system requires only the addition of two separate columns of basic vector dimensions with their respective tolerances attached, and the algebraic addition (considering opposite direction as apposite signs) of the totals of these columns.

Vectors by definition have both direction and magnitude. Dimensions have magnitude. All that must be done, therefore, to convert a dimension into a vector is to remove, physically or mentally, one arrow-head to give the dimension a chosen direction.

The choice of directions of all the vector dimensions is made so that the successive vectors when placed together will join head to tail, in the normal fashion, to make a vector diagram. The tolerances, likewise, are considered to be small vectors having direction and magnitude. If one desires a position for them, they may be placed beside the basic vector dimensions to which they apply or in the vicinity of the resultant vector to which they will finally apply.

In this system, it is only necessary to realize that a plus sign before a tolerance means that the tolerance goes in the same direction as the basic vector dimension to which the tolerance applies. And also that a minus sign means that the tolerance goes in the opposite direction.

Since tolerances are forever existent or available for use after assignment, never cancelling but always accumulating, it is logical that they should be totalled under their respective true directions. The vector tolerances which will group together, Fig. 1, or add together because their directions are the same, therefore, represent dimension tolerances with like signs only when the assumed directions of the basic dimensions are the same.

Signs of tolerances, being dependent on the signs of the basic vectors, must be considered whenever any change of sign is made to the basic vector. For this reason, algebraic addition is used when vectors representing tolerances of basic vector dimensions of opposite direction and sign are combined.

Unilateral, bilateral and mixed tolerances are handled with nearly equal ease under this system. Most assemblies using the coordinate dimensioning system make comparatively easy vector diagrams, since the dimensions along the respective axes can be treated separately. The system is still applicable even if the drawing contains angular dimensions from which certain of the coordinate dimensions must be obtained by the normal trigonometric means.

The simple block example, Fig. 2, indicates the basic considerations associated with the use of the vector dimensioning system. In this example, the problem is to find the unknown distance $\overline{AB}$. Going from A to B vectorially, the first step in the solution is to consider the four dimensions on the bottom row as vectors directed toward the right, and the two dimensions on the top row as vectors directed toward the left. The second step, as shown in Fig. 2, is to write these values in columns corresponding to their respective directions; then, total

* *The data presented in this article are those of the author and are not to be construed as official data released by the United States Department of the Army.*

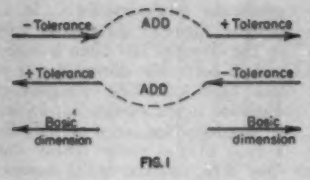
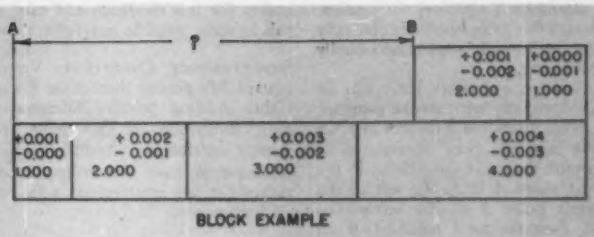
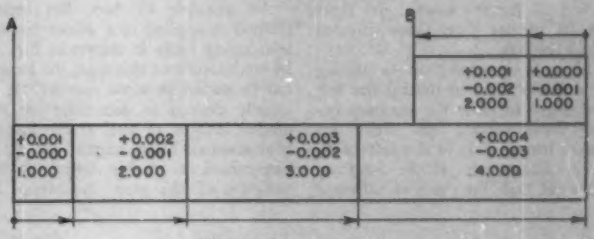


FIG. 1

Fig. 1—Addition of tolerance vectors having same direction regardless of signs. Vector tolerances that group together represent dimension tolerances with like signs only when assumed directions of basic dimensions are the same.



BLOCK EXAMPLE



FIRST STEP IN SOLUTION

Fig. 2—Simple block problem and steps in its solution using the vector dimensioning system. Problem is to find the unknown distance between A and B. Solution indicates basic considerations associated with vector system.

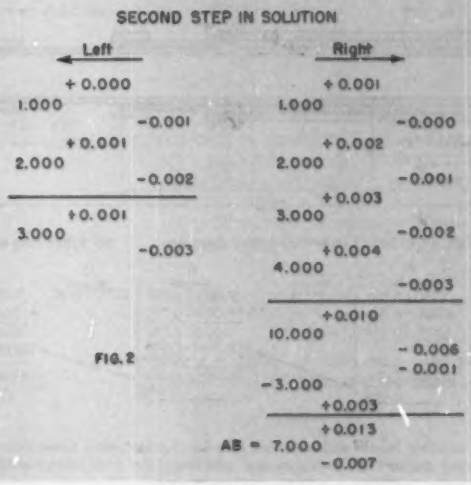


FIG. 2

Fig. 3—A vector directed toward the left is necessary to close this diagram. Conversely, B is to the left of A when the total resultant of all the vectors directed toward the left is greater than those directed toward the right.

FIG. 3

the columns and add algebraically the column totals in the manner shown.

The resultant $\overline{AB}$ is a dimension 7.000 with a plus tolerance of 0.013 and a minus tolerance of 0.007. Therefore, 7.013 is the maximum value and 6.993 is the minimum value.

With the vector system the drawing dimensions are recorded exactly without any intervening computations. The drawings and the tabulations, therefore, can be compared directly and the numbers can be "checked-off" when they agree.

In complex problems, a number of dimensions may be included in the determination of the distances between mating surfaces. This condition does not affect the system, since only continuity of vectors is required. Whether or not the direction of successive vectors changes is of little consequence as long as the vectors continue from one dimension line to the other without interruption and join head to tail. This statement does not imply that assemblies having more than one unknown dimension cannot be solved by the vector method.

When solving problems that include more than one unknown, labeled vectors should be used with directions assumed that do not conflict with the continuity of the vector diagram. The assignment of answers to the unknowns is then accomplished by separating the total resultant into dimensions to suit the requirements.

When using the vector system, it is recommended that the smaller resultant be subtracted from the larger resultant, which consequently changes the signs of the tolerances of the smaller. Such procedure results in answers for the final resultant dimension and tolerances that can be more easily interpreted. Otherwise, if the larger resultant were subtracted from the smaller resultant the final resultant vector dimensions would be negative integers, the negative tolerance of which would produce the maximum (negative) dimension; and the positive tolerance of which would produce

the minimum (negative) dimension. Although the procedure is theoretically correct, such results would undoubtedly be confusing.

In isolated assemblies, there may be some uncertainty whether the resultant represents interference or clearance. A simple rule has been formulated to determine the exact condition. If the starting point *A* is on the left of the finishing point *B* of the vector diagram, then the total resultant of all the vectors directed toward the right must be greater than those directed toward the left.

This rule is equivalent to stating that a vector directed toward the left is necessary to close the diagram because those toward the right are greater; hence, *A* is to the left of *B*, Fig. 3. Conversely, if the total resultant of all the vectors directed toward the left is greater than those directed toward the right, then *B* is to the left of *A*. If the total resultant of the vectors directed toward the right is equal to the total resultant of the vectors directed toward the left than *A* coincides with *B*; and, of course, their difference is zero, but the tolerances must still be considered.

CLEARANCE CONDITION: Vectors toward right greater than those toward left. Adding positive tolerance to basic dimension of $\overline{AB}$ makes for greater clearance. Adding negative tolerance to basic dimension of $\overline{AB}$ makes for less clearance and may result in some possible interference.

INTERFERENCE CONDITION: Vectors toward left greater than those toward right. Adding positive tolerance to basic dimension of $\overline{AB}$ makes for greater interference. Adding negative tolerance to basic dimension of $\overline{AB}$ makes for less interference with possible clearance.

An example of how the vector method is applied to a device having telescoping tubes is shown in Fig. 4. In mechanisms of this type, the length can be varied in some manner. It is usually desired to determine the extended lengths as well as the assembled length. These lengths are often determined, as in this design, by the position of the stop shoulders. In Fig. 4, the computations are given for determining the lengths (as measured between the centers of the mounting holes in the end caps) when all tubes are closed, when only the innermost tube is fully extended, and when all tubes are fully extended.

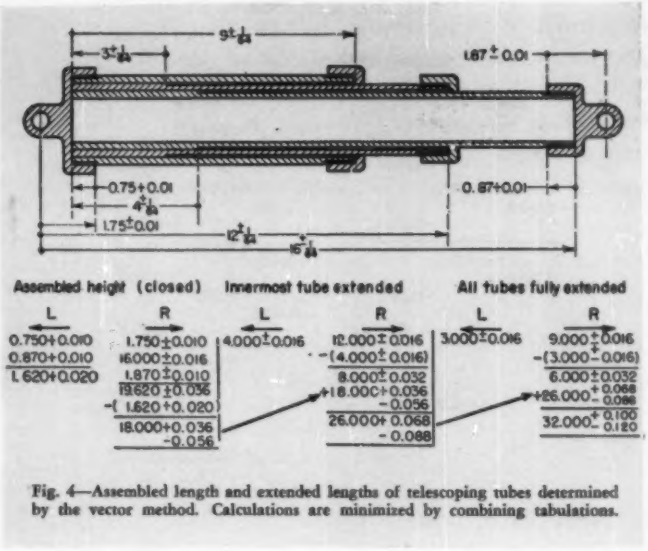


Fig. 4—Assembled length and extended lengths of telescoping tubes determined by the vector method. Calculations are minimized by combining tabulations.

The work required in the example of Fig. 4 has been minimized by combining the tabulations for obtaining the various lengths. When only one answer is required, however, all unnecessary subtotals should be eliminated by employing the most direct method.

To further explain the versatility of the vector dimensioning system, various conditions of members having pin or bolt connected joints will be considered. For simplicity, the pins of the joints will be assumed to be perpendicular to the members. In such designs, diameter dimensions appear on the drawings and often it is necessary to use radius dimensions as vectors. From a checking standpoint, this condition is unfortunate but it cannot be avoided. Nor can it be considered a fault of the vector system alone; since radii, and also radial clearances, of necessity enter into all systems of checking.

A system of pin connected tension members is shown in Fig. 5. The same system is shown in Fig. 6 except that the members are in compression. For both conditions of loading, the variation of member positions is clearly shown together with the shift in bearing surfaces and the centerline position of the holes. Note the contrast in the resultant dimensions.

For purposes of illustration, the holes in the pair of members in both Figs. 5 and 6 have been considered as unequal in size. In practice, the holes are usually of the same diameter, and the problem is simplified.

In Fig. 7, which shows pin connected members having holes of equal diameters, a vector *C* has been added. This vector represents the displacement of the centerlines of the holes of the joint, and is equal to the total clearance, that is, the allowance together with the tolerances of one hole and the pin. Only one hole is considered because both holes are the same diameter. The first or basic part of the *C* vector dimension as computed and written is the allowance, and the second portion is the tolerance or tolerances.

One of the most convenient ways of considering this problem is to imagine that the centerlines are congruent in order to obtain a resultant vector dimension for an on-center condition. Then to this dimension add or subtract, as required, the displacement of the centerlines according to the type of load.

If the resultant obtained, when the centers are considered congruent, is called *R*; then when the members have opposing tension loads as in Fig. 7 (*A*)

$$X = R + C$$

when these members are in compression as in Fig. 7 (*B*)

$$X = R - C$$

when the pin fits the holes snugly as in Fig. 7 (*C*)

$$C = 0, \text{ and } X_a = R$$

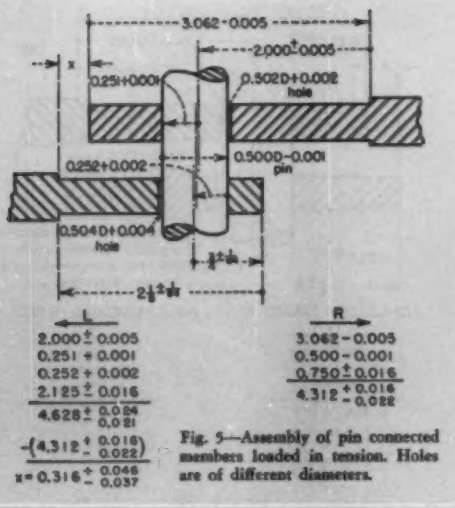


Fig. 5—Assembly of pin connected members loaded in tension. Holes are of different diameters.

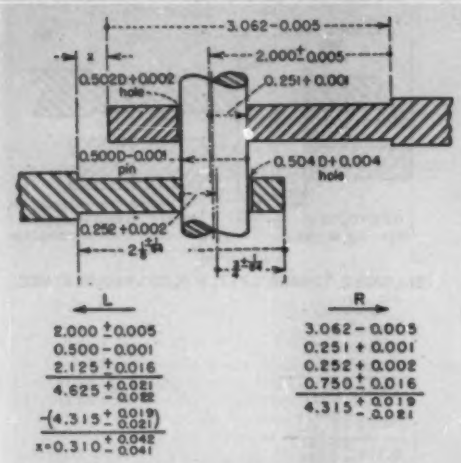
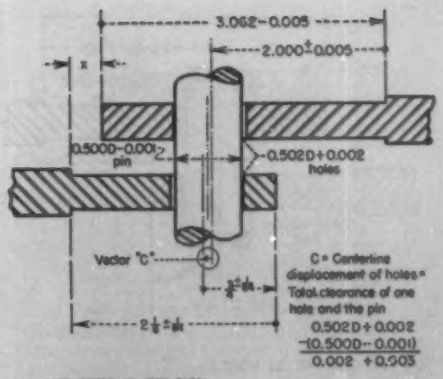


Fig. 6—Assembly of pin connected members loaded in compression. Holes are of different diameters.



(A) MEMBERS IN TENSION

L	R
2.000 ± 0.005	3.062 - 0.005
"C"	0.750 ± 0.016
2.125 ± 0.016	3.812 + 0.016 / - 0.021
4.125 ± 0.021 + C	
-(3.812 ± 0.016 / 0.021)	
0.313 ± 0.042 / 0.037 + C	
0.313 ± 0.042 / 0.037	
0.002 + 0.003	
x = 0.315 ± 0.045 / 0.037	

(B) MEMBERS IN COMPRESSION. BY INSPECTION, IT CAN BE SEEN THAT THE ONLY VECTOR AFFECTED BY REVERSAL OF LOADING IS THE VECTOR "C", WHICH SIMPLY CHANGES DIRECTION. THUS, IN THE CALCULATIONS, IT MUST BE SUBTRACTED INSTEAD OF ADDED AS IT WAS IN THE TENSION CASE.

$$0.313 \pm {}^{0.042}_{0.037}$$
$$-(0.002 + 0.003)$$
$$x = 0.311 \pm {}^{0.042}_{0.040}$$

(C) MEMBERS SNUG FIT WITH PIN, C = 0 (MEMBERS IN TENSION OR COMPRESSION)

$$x = 0.313 \pm {}^{0.042}_{0.037}$$

Fig. 7—Pin connected members, holes are equal size. (A) In tension. (B) In compression. (C) Snug fit.

This method of starting with the members in a neutral or centered position is also a convenient way to proceed with reciprocating members, in such designs the total clearance of one hole and pin is both added and subtracted. For example, when the centers in Fig. 7 are considered congruent

$$X = 0.313 \pm {}^{0.042}_{0.037}$$

then from Figs. 7 (A) and (B)

$$C = 0.002 + 0.003$$

or

In tension, $X = 0.313 + 0.042 + (0.002 + 0.003) = 0.360$

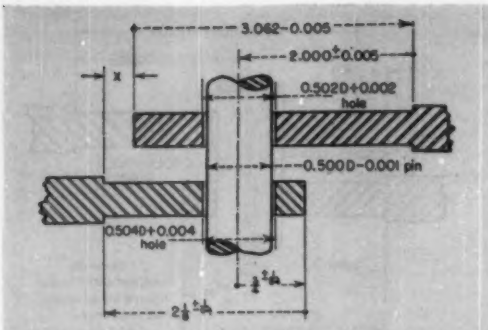
In compression, $X = 0.313 - 0.037 - (0.002 + 0.003) = 0.271$

A check will show that these values correspond to the two extreme values of all the answers given in the Figs. 7 (A) and (B) tabulations.

To further amplify this discussion, the resultants of Figs. 5 and 6, in which the holes are not equal in size, have been obtained in Fig. 8 using the combined method that includes the use of the values of clearances. Fig. 8 also gives the method of obtaining the resultant in designs where the members are reciprocating and the extreme dimensions are required.

To conclude the discussion of single pin connected joints consider a joint, Fig. 9, that has a fixed pin connecting two members loaded in the same direction. In such problems, the pin can usually be neglected if it is uniform in diameter, because it only serves to align the sides of the holes.

It is convenient to solve the problem given in Fig. 9, by first considering the hole centerlines congruent and then shifting the members until the proper sides of the holes are in line or against the pin as shown in Fig. 10. In this type of joint, usually the X dimension can be held closer when



(A) PIN CENTRAL IN HOLES

L	R
2.000 ± 0.005	3.062 – 0.005
2.125 ± 0.016	0.750 ± 0.016
4.125 ± 0.021	3.812 ± 0.016 / 0.021
–(3.812 ± 0.016 / 0.021)	
x = 0.313 ± 0.048 / 0.037	

Top member	Bottom member
0.502 ± 0.002 D. hole	0.504 + 0.004 D. hole
–(0.500 – 0.001) D. pin	–(0.500 – 0.001) D. pin
0.002 + 0.003 Total clearance	0.004 + 0.005 Total clearance

* Average total clearance (0.003 + 0.004)

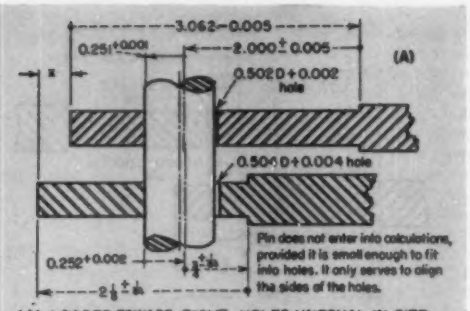
Maximum average * Total clearance 0.007

(B) MEMBERS DISPLACED FROM CENTERED POSITION AS A RESULT OF ACTION OF

Tension forces	Compression forces	Alternating tension and compression forces
0.313 + 0.048 / 0.037	0.313 + 0.048 / 0.037	0.313 + 0.048 / 0.037
+(0.003+0.004)	–(0.003+0.004)	± 0.007
0.316 + 0.048 / 0.037	0.310 + 0.048 / 0.041	0.313 + 0.049 / 0.044

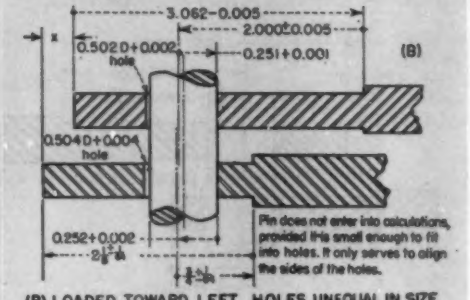
* Arithmetical mean

Fig. 8—Unequal holes. (A) Pin central. (B) Members displaced as a result of reciprocating forces.



(A) LOADED TOWARD RIGHT, HOLES UNEQUAL IN SIZE

L	R
2.000 ± 0.005	3.062 – 0.005
0.251 + 0.001	0.252 + 0.002
2.125 ± 0.016	0.750 ± 0.016
4.376 + 0.022 / – 0.021	4.064 + 0.018 / – 0.021
– (4.064 + 0.018 / – 0.021)	
x = 0.312 + 0.043 / – 0.039	



(B) LOADED TOWARD LEFT, HOLES UNEQUAL IN SIZE

L	R
2.000 ± 0.005	3.062 – 0.005
0.252 + 0.002	0.251 + 0.001
2.125 ± 0.016	0.750 ± 0.016
4.377 + 0.023 / – 0.021	4.063 + 0.017 / – 0.021
– (4.063 + 0.017 / – 0.021)	
0.314 + 0.044 / – 0.038	

Fig. 9—Fixed pin connecting two members loaded in the same direction. Holes are unequal in size.

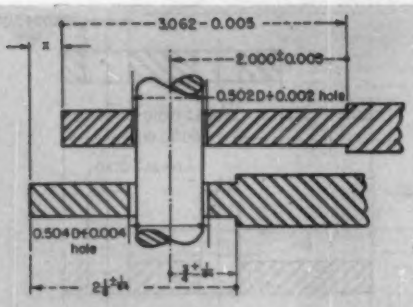
the pin connected bars are loaded in the same direction than when they are loaded in opposite directions. The reason is that the bars shifting in the same direction make the relative location of the bars dependent only on the radial differences in size of the holes. This radial difference in most designs is rather small, and does not exist when the holes are equal in size.

When two or more pins or bolts are used to connect members, the solution of the problem is slightly more difficult. In designs where counterbores exist, the problem is still further complicated; since not only must the shanks of the bolts be considered but also the heads and possibly the lock washers under the heads. The solution, although more laborious is obtained through an amplification of simple problems and the application of the general principles of vectors.

Multiple Pin Joint Problems and Their Solution

The three pin joint shown in Fig. 11 is dimensioned in two different ways. The first method, Fig. 11 (A), requires only one-half of the hole and pin allowance necessary under the second method, Fig. 11 (B). The method used in Fig. 11 (A) is preferred but other factors governing locations may require that the center pin control, in which event the allowances should be taken care of or provisions made to locate holes at assembly or to use select fit methods.

In the two pin joint shown in Fig. 12, the pins are fixed or threaded into one member. In an investigation to determine if the members will go together without interferences, the allowances and tolerances that make up the clearances of the individual holes and pins should logically be considered first, Fig. 12 (A). Then, the center



(A) PIN CENTRAL IN HOLES

L	R
2.000 ± 0.005	3.062 − 0.005
2.125 ± 0.016	0.750 ± 0.016
4.125 ± 0.021	3.812 +0.016 −0.021
−(3.812 +0.016 −0.021)	
x = 0.313 +0.042 −0.037	

Pin does not enter into calculations, provided it is small enough to fit into holes, it only serves to align the sides of the holes

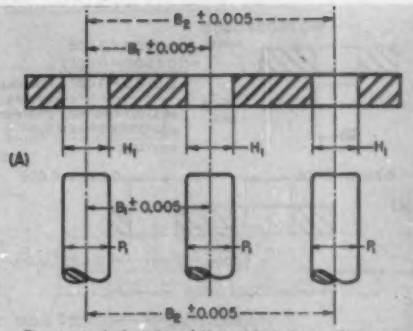
0.504D + 0.004	
− 0.502D − 0.002	
0.002	+ 0.004 − 0.002 Difference of diameters of holes
0.001	+ 0.002 − 0.001 Radial difference

(B) MEMBERS DISPLACED FROM CENTERED POSITION AS A RESULT OF ACTION OF

Loads toward left	Loads toward right
0.313 +0.042 −0.037	0.313 +0.042 −0.037
+(0.001 +0.002 −0.001)	−(0.001 +0.002 −0.001)
0.314 ± 0.044 − 0.038	0.312 +0.043 −0.039

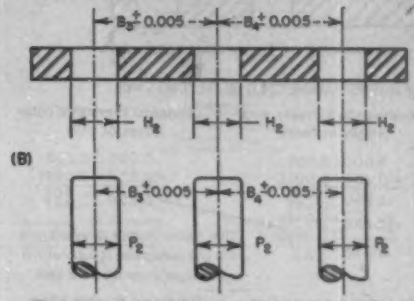
NOTE: If holes in members were equal in diameter and loads were in the same direction, "x" would be the same if the loads were from the left as it would be if the loads were from the right, and "x" would be equal to the value shown for the condition of the pin centrally located in the holes.

Fig. 10—Alternate method for fixed pin connecting two members loaded in same direction having unequal holes.



The nominal diameter of H_1 must include an allowance of 0.010 over and above the nominal diameter of R_1

The sum of the allowances of each pair of mating holes and pins must equal the sum of the tolerances of the hole and pin center distances concerned without regard to signs.



The nominal diameter of H_2 must include an allowance of 0.020 over and above the nominal diameter of P_2.

The allowance for this method of dimensioning is double that required when dimensioned according to method (A)

The reason for this becomes apparent when one notices that the tolerances of B_3 and B_4 must be included in the center distances of the two outside holes and pins.

The method of dimensioning shown in (B) should only be used when sufficient allowances are permissible.

The fact that the tolerances do not accumulate in the dimensioning method shown in (A) is the reason why it is recommended for all applications involving a number of holes in a relatively straight row.

Fig. 11—Three pin joint. Comparison of methods of dimensioning to show the effect on allowances required.

distances must be checked for alignment of pins with their respective holes under conditions as set forth by the other drawing dimensions, Fig. 12 (B). From the standpoint of interchangeability, it is not permissible to have interferences under these conditions; therefore, the factors leading to prevention of interferences should be clearly understood.

In Fig. 12, it is shown that interferences will be prevented whether or not bilateral tolerances are used, if the total of the allowances of the two holes and pins is at least equal to the total of the tolerances disregarding signs of the equal center distances. It is further shown in this problem, that the hole and pin tolerances are used mainly for the prevention of high machining cost, and as an aid in assembly, but the possibility of increased shift of the members can at times be detrimental.

Another feature included in the problem of Fig. 12 is the determination of the controlling pin and hole combination. This information is necessary for the calculation of relative member locations. Since it was found that the problem was set-up in such a manner that both pins just touched the sides of the holes under the two extreme conditions, the relative location is obtained from just one of the two combinations of holes and pins. As a result of the method of dimensioning, the right pin and hole will permit the least amount of shift, and will therefore control by constraining the linkage before any additional shift can be contributed by other means.

The knowledge gained from the one and two pin joint problems is applicable to the three or greater number of pin joint problems. The possibility of excessive accumulations, however, with its subsequent requirement of greater

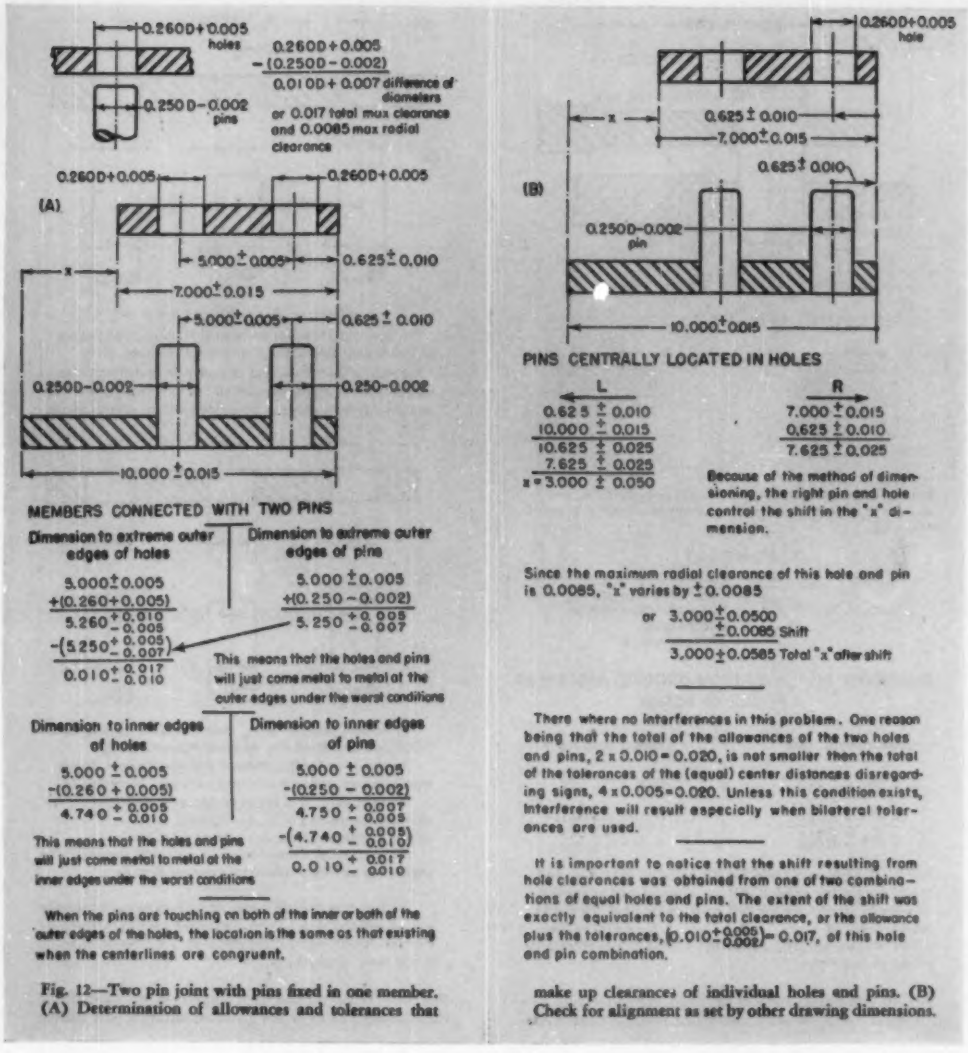

0.260D+0.005 holes
0.250D−0.002 pins
0.260D+0.005
−(0.250D−0.002)
0.010D+0.007 difference of diameters
or 0.017 total max clearance and 0.0085 max radial clearance
(A)
0.260D+0.005
0.260D+0.005
5.000±0.005
0.625±0.010
x
7.000±0.015
5.000±0.005
0.625±0.010
0.250D−0.002
0.250−0.002
10.000±0.015
MEMBERS CONNECTED WITH TWO PINS
Dimension to extreme outer edges of holes
5.000±0.005
+(0.260+0.005)
5.260 +0.010 −0.005
−(5.250 ±0.005 −0.007)
0.010 +0.017 −0.010
Dimension to extreme outer edges of pins
5.000±0.005
+(0.250−0.002)
5.250 +0.005 −0.007
This means that the holes and pins will just come metal to metal at the outer edges under the worst conditions
Dimension to inner edges of holes
5.000±0.005
−(0.260+0.005)
4.740 ±0.005 −0.010
Dimension to inner edges of pins
5.000±0.005
−(0.250−0.002)
4.750 +0.007 −0.005
−(4.740 ±0.005 −0.010)
0.010 +0.017 −0.010
This means that the holes and pins will just come metal to metal at the inner edges under the worst conditions
When the pins are touching on both of the inner or both of the outer edges of the holes, the location is the same as that existing when the centerlines are congruent.
0.260D+0.005 hole
(B)
x
0.625±0.010
7.000±0.015
0.625±0.010
0.250D−0.002 pin
10.000±0.015
PINS CENTRALLY LOCATED IN HOLES
L
0.625 ±0.010
10.000 ±0.015
10.625 ±0.025
7.625 ±0.025
x = 3.000 ±0.050
R
7.000 ±0.015
0.625 ±0.010
7.625 ±0.025
Because of the method of dimensioning, the right pin and hole control the shift in the "x" dimension.
Since the maximum radial clearance of this hole and pin is 0.0085, "x" varies by ±0.0085
or 3.000±0.0500
±0.0085 Shift
3.000±0.0585 Total "x" after shift
There where no interferences in this problem. One reason being that the total of the allowances of the two holes and pins, 2 x 0.010 = 0.020, is not smaller than the total of the tolerances of the (equal) center distances disregarding signs, 4 x 0.005 = 0.020. Unless this condition exists, interference will result especially when bilateral tolerances are used.
It is important to notice that the shift resulting from hole clearances was obtained from one of two combinations of equal holes and pins. The extent of the shift was exactly equivalent to the total clearance, or the allowance plus the tolerances, (0.010±0.005 −0.002) = 0.017, of this hole and pin combination.

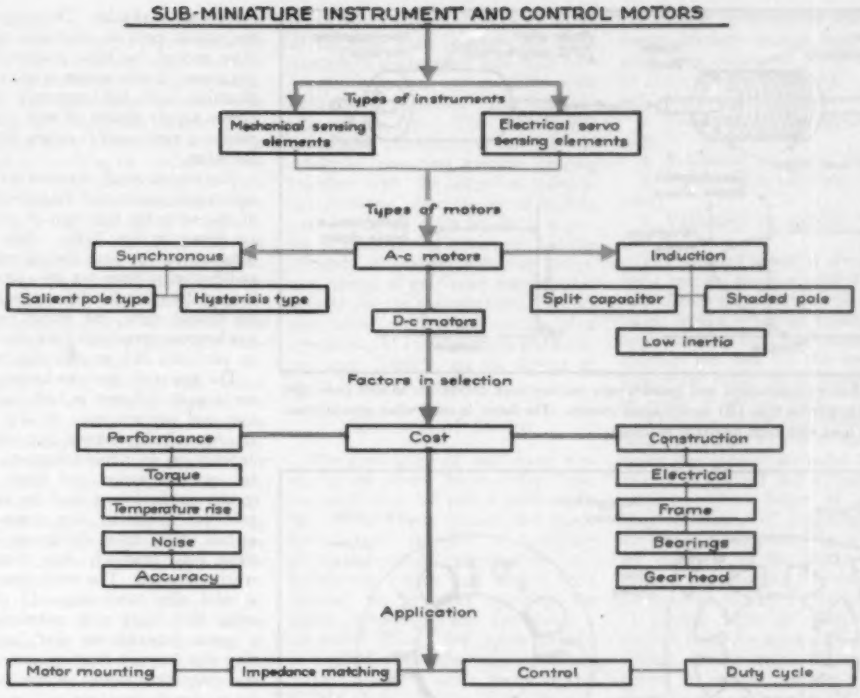
Fig. 12—Two pin joint with pins fixed in one member. (A) Determination of allowances and tolerances that make up clearances of individual holes and pins. (B) Check for alignment as set by other drawing dimensions.

allowances, increases with the number of pins or bolts used in the joint. For this reason, the use of the generally preferred dimensioning arrangements and the acceptable clearance values are recommended. The use of vectors facilitates the determination of the best means of dimensioning and the minimum allowances required.

Since the general practice in other engineering work is to apply signs to vectors immediately after the directions have been determined, it would appear desirable to follow this practice in dimensional studies. In this work, however, the disadvantage of this general system offsets the advantage. For instance, if the right direction was always assumed to be positive, then the condition of fit, whether interference or clearance, would be indicated by the sign of the basic resultant vector provided consideration is given to the origin of vectors.

This apparent advantage is offset by the difficulty of interpreting tolerance signs, for in many instances the basic portion of the resultant would be a negative integer, which in turn means that the negative tolerance would yield the maximum numerical value and the positive tolerance the minimum numerical value. At this point, the signs could be changed, but if any part of this operation is incorrectly handled or forgotten erroneous answers would result.

On the other hand, if the vector method described in this article is used, and the simple rule for determining the condition of fit is applied particularly in the questionable cases, very little difficulty should be encountered. Regardless of the method of handling signs utilized, which may be a matter of personal preference, the vector dimension system is superior to other commonly used systems.



Sub-Miniature Instrument And Control Motors

Selecting the correct electrical motor for your instrument or electrical servo is important from the standpoint of initial cost, maintenance cost, and performance. The author tells you how to go about it, and discusses the characteristics of the various types.

JOSEPH K. RAES
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GENERALLY, ELECTRICAL MOTORS are used in the instrument field in one of three fundamental ways: To operate in conjunction with a mechanical sensing element to transcribe a small variable into a measurable quantity that can be indicated or recorded; to drive timing devices at a synchronous speed; to take the output from error detecting or sensing elements in a servomechanism and drive suitable error correcting and recording devices; or—as is often the case—to do a combination of all three. Therefore, the initial factor governing the selection of a suitable motor is the function that the motor must serve and the type of power supply, a-c or d-c, that is available.

If the motor is to amplify the output from a sensing element, the mechanism is usually driven at constant speed and the variation applied to the recorder periodically. The recording chart thus must be accurately marked in time units and be driven synchronously, which can be done with a synchronous clock-type motor. In many cases, however, synchronous power must also be provided for the ampli-

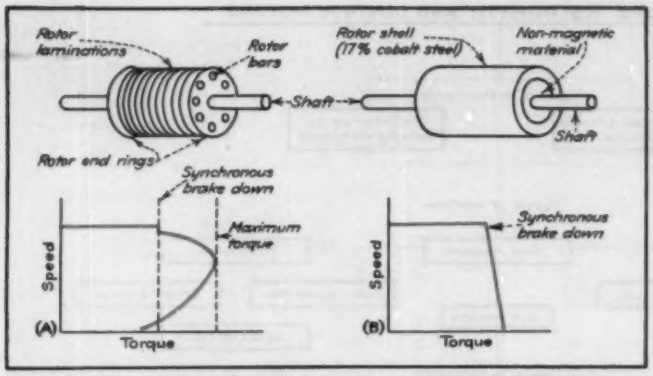


Fig. 1—Rotor construction and speed-torque performance curves for salient pole type (A) and hysterisis type (B) synchronous motors. The latter is used when synchronization of a load with high inertia is required.

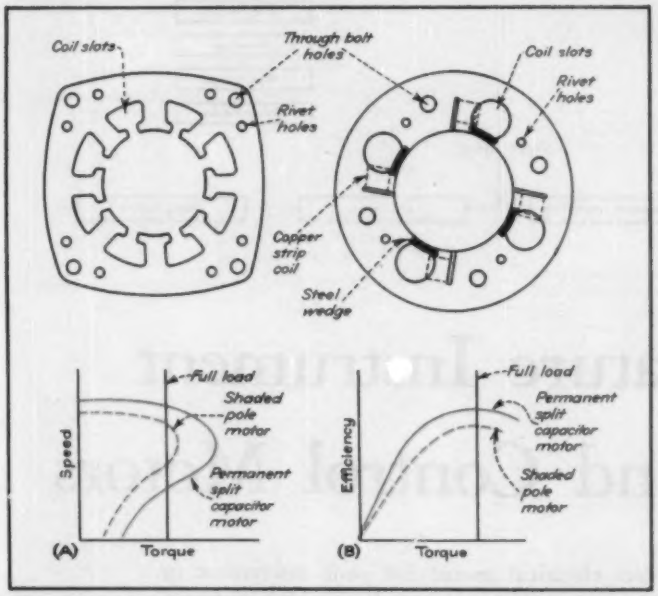


Fig. 2—Stator lamination and comparative performance curves for permanent split-capacitor induction motor (A) and shaded pole induction motor (B). The efficiency of the former approaches the efficiency of a two phase motor.

fication of the sensing power and to drive the control, so a more powerful motor is required.

If, on the other hand, the motor is to be used in an electrical servo system, either a synchronous or induction type may be employed. Precise control of speed and direction of rotation can be obtained from either of these types when wound for two-phase power with one phase excited from the line and the other phase from an electronic amplifier that amplifies the signal from a sensing element, as discussed later.

Of course, d-c rather than a-c motors are necessarily used for some applications, particularly on aircraft, but not to a large extent elsewhere. But discounting the d-c motor for the moment, the sub-fractional hp motors that fulfill requirements for the majority of instrument and control applications are as follows:

SYNCHRONOUS MOTORS. Either salient pole or hysterisis type synchronous motors are available. The accuracy of the salient pole or reluctance type is close enough for most instrument applications; if this motor is not in synchronism with the frequency of the power supply system, it will slip one pole at a time until it comes into synchronism.

The torque-speed characteristics of a salient pole motor and the construction of the rotor for this type of machine are shown in Fig. 1(A). The stator construction for both the salient pole and hysterisis types are the same. At the synchronous breakdown point on the torque curve, the motor loses its synchronous speed and from that point on performs like an induction motor.

The hysterisis type synchronous motor is quite different in both construction and performance. It also is an accurate timing motor but since it depends on its induced magnetic poles for synchronization and since under certain conditions of load the induced pole can gradually slip around the surface of the rotor, the driven instrument may gradually lose time and synchronization. The rotor consists of a solid alloy steel ring—17 percent cobalt steel being quite common—and a spacer between the shaft and this ring that may be brass or some other non-magnetic material. When this motor reaches the synchronous breakdown point on the torque speed curve, the speed drops to zero with practically no increase in torque. On the other hand, the salient pole synchronous type motor will produce additional torque between the synchronous breakdown point and the maximum torque point.

The hysterisis motor is used when a load having considerable inertia must be synchronized, while the salient pole motor is used when positioning of the driven device with respect to the motor input voltage is important. In other respects, the two types are about equal. However, care must be exercised when applying a hysterisis motor since its synchronous torque decreases with increased input voltage after a certain voltage is reached.

INDUCTION MOTORS. Conventional induction motors are used in instruments requiring power for such operations as valve actuating, potentiometer positioning, or condenser tuning. The induction motor may be of the permanent split capacitor, or shaded pole type. Split phase motors are not in general use in the miniature sizes because the space available does not permit the use of a centrifugal switch, and also because the performance of the two types listed is superior to that which could be secured from a split phase miniature motor. The shaded

pole motor has the advantage of low cost, the disadvantages of low efficiency and lack of versatility; also, it cannot be reversed although certain manufacturers are producing motors with shading coils to permit reversing.

Typical stator laminations are shown in Fig. 2 for these two induction motors. The rotor construction for each is the same. The permanent split capacitor stator lamination is for a 4-pole motor. After the laminations are riveted together to form the stator core, four working winding coils are inserted into the slots. The four starting winding coils are also inserted into these slots and are permanently connected to a capacitor.

Similarly, the shaded pole stator laminations are riveted together to form a stator core. Copper strips are passed through the narrow rectangular slots around the coil slots and the ends are joined. These strips are necessary to secure adequate starting torque. The winding coils are inserted into their slots and retained by steel wedges that fit into the dovetail form of the laminations.

The permanent split capacitor induction motor is in general use where it is desired to control the direction of rotation or the speed at a device or to secure dynamic braking. It is the most efficient type of single phase motor since its performance approximates that of a two phase motor, as indicated by the comparative performances of shaded pole and permanent split capacitor motors. It is difficult to insert values on these illustrations because design features can vary the values. Usually, for similar designs, the shaded pole motor will operate at about 10 percent lower speed and closer to the maximum torque point than the permanent split capacitor type.

Low Inertia Motors are special induction motors constructed to permit the use of a small rotor diameter. These motors are used where extremely rapid reversing or braking is essential. Probably the most universal application for such a motor is in driving a pen on a recording chart where precise and rapid positioning of the pen is required. Frequently, this motor is part of a servo system wherein the motor drives some device such as a potentiometer which controls the desired quantity, and by movement of that device returns the system to the desired value. The construction of the low inertia motor makes this type inherently more expensive than the conventional induction motor. For this reason, it should be used only when the inertia of the conventional motor makes it unsuitable.

Gear-Head Motors. The high speed of the rotor shaft is rarely employed directly in instruments, and most subfractional motors are available with built-in gear reduction trains, irrespective of the type. This relieves the instrument manufacturer of the necessity of providing external gearing together with the attendant lubrication problems. Also, the use of built-in gear reductions often results in a saving of space in the instrument, but the methods of gearing, reduction ratios, and ratings of gear-head motors again depend on the manufacturer. Reduction ratios and torque ratings of a typical line of induction and synchronous units, Table I, are for motors of up to 1/500 hp capacity.

Selection of Motor

The application of instrument motors to the driven device differs from the application of power motors. In the case of power motors, the motor manufacturer provides a nameplate giving the voltage, current, speed and horsepower rating, and with a little caution, the engineer applying the motor to his equipment can obtain a successful drive. Far more caution is required when selecting a miniature motor, especially since there are no NEMA standard types or size ratings.

It is good practice when designing a new instrument, to secure a sample motor for test purposes. This sample motor might well be a standard stock item, and readily procurable. This motor would then be assembled to the driven device and tested. It is not enough to determine whether the motor develops enough torque; there must be a margin of safety sufficient to allow for the following:

1. Variations in motors
2. Variations in the driven equipment
3. Variations in supply voltage
4. Variations in capacitor value (if used)
5. Variations in ambient temperature

The standard motor is not designed for a specific purpose, and it is more than likely that a modified standard motor would be better suited for the application. The modifications may increase the cost of the motor but frequently result in a greater factor of safety in performance.

When the torque requirements have been determined by test of the sample motor, the appropriate factor of safety should be applied and a specification prepared. The factor of safety is largely a matter of judgment. Since the torque developed by the motor varies inversely as the square of the voltage, and since the line voltage may be expected to vary by 10 percent, a 21 percent factor of safety must be applied from the standpoint of supply voltage alone. Since the torque required to operate production instruments may be as much as 20 percent greater than the sample tested, this factor must be multiplied by the factor for voltage variation.

If a maximum ambient temperature of 50 C is to be encountered, the motor torque may be expected to drop about 10 percent from its value at normal

Table I—Motor Ratings at 115 Volts A-C of a Typical Gear-head Motor Line[1]

60 Cycle Motors		25 and 50 Cycle Motors		Rated Torque, oz. in.	
Gear Ratio	Syn. Speed	Gear Ratio	Syn. Speed	Synchronous	Induction
.....	1800	.....	1500	0.15	0.3
6/1	300	5/1	300	0.6	1.2
15/1	120	12.5/1	120	1.5	2.6
18/1	100	15/1	100	1.5	3.0
30/1	60	25/1	60	3.0	6.0
36/1	50	30/1	50	4.0	8.0
60/1	30	50/1	30	6.0	12.0
90/1	20	75/1	20	9.0	18.0
120/1	15	100/1	15	11.0	22.0
180/1	10	150/1	10	12.0	24.0
225/1	8	187.5/1	8	15.0	30.0
300/1	6	250/1	6	20.0	40.0
360/1	5	300/1	5	25.0	50.0
450/1	4	375/1	4	30.0	60.0
600/1	3	500/1	3	40.0	75.0
900/1	2	750/1	2	60.0	75.0
1800/1	1	1500/1	1	75.0	75.0

[1] Ratings are for motors of up to 1/500 hp capacity.

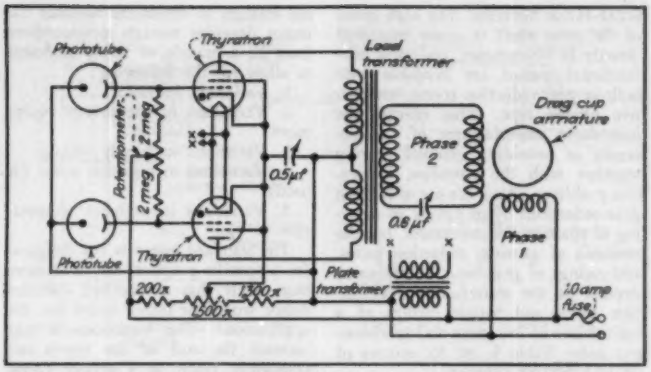


Fig. 3—Control circuit for regulating the direction of rotation and speed of a two phase motor by means of the differential in light intensity falling on two phototubes.

temperatures. Another 10 percent variation in performance may be normally expected from variations in capacitor value. The product of these four factors, then, or 76 percent is the amount by which the torque required to operate the sample instrument should be increased. Frequently, the root-mean-square of these percentages is used. The value thus arrived at is to be incorporated in the motor specification as "minimum starting torque" or "minimum breakdown torque." In the case of synchronous motors, the required synchronous pull-in torque should also be determined and specified. The motor manufacturer must guarantee that he will permit no motors to pass his test that do not at least equal the minimum limits.

The temperature rise of the motor when mounted in its operating position and when operating under its most rigorous duty cycle must be measured. Probably the most satisfactory method of securing the temperature rise is by resistance increase. A temperature rise limit must be established with due regard for duty cycle. A duty cycle expressed only as a percentage means nothing to the motor manufacturer. The "on" time and "off" time must be specified. The miniature motor usually attains 75 percent of its ultimate temperature rise after about twenty minutes of operation, but in many instrument applications, the motor operates only a fraction of that time; in such cases, the motor can be provided with a special winding and/or a special rotor, although this usually means that the motor is capable of intermittent operation only.

The lubricant in the motor bearings and in the gear train operates at a temperature that approximately equals the temperature of the motor windings. This is especially true of miniature motors of the type used in instruments; the temperature gradient between the winding and the outside of the frame rarely exceeds 5 C.

This fact restricts the maximum operating temperature and hence the winding strength for a given motor frame size. It also restricts the maximum ambient temperature in which a given motor design may be used. For satisfactory lubricant life, the operating temperature of the motor should not exceed 90 C; and even then, lubricant should be added every two or three months. Certain lubricants are available (at higher prices) that will successfully withstand higher temperatures, but when the motor temperature materially exceeds 90 C, the winding insulation deteriorates rapidly.

The temperature rise limit may be established by subtracting the maximum ambient temperature in which the motor is to be operated from 90 C. In this instance, a considerable portion of the responsibility lies with the instrument manufacturer, since he provides the mounting and therefore the effective radiating surface for the motor.

Where vacuum tube control is to be used, impedance limits for the control winding should be specified. Most servo systems require the use of vacuum tube control for motors: This imposes the requirement that the winding impedance be high and that the motor be capable of developing adequate torque when supplied with the low currents that tubes can provide. Motors of this type usually employ a two phase winding, one winding having normal impedance and supplied directly from the power line. The second winding or "control-phase" is wound for such power as is available from the control means. In some cases, a center tap is brought from the control phase to permit push-pull operation of the vacuum tube control.

For example, the photoelectric control circuit in Fig. 3 is used to regulate the speed and direction of rotation of a sub-miniature two phase motor. Two thyratrons are used in a bridge balance circuit, which is completely controlled by a-c power. With this circuit, the speed and direction of the rotation depends on which phototube receives the most light. If each receives equal illumination, the motor stops. Initial balance between the circuit components is accomplished by the potentiometer in the grid return circuit. The 0.5 μf capacitor between the load transformer center tap and the cathodes is used to prevent the firing of the thyratrons. The 0.6 μf capacitor in the second phase circuit is also adjustable to provide an initial 90 deg shift between windings of the motor.

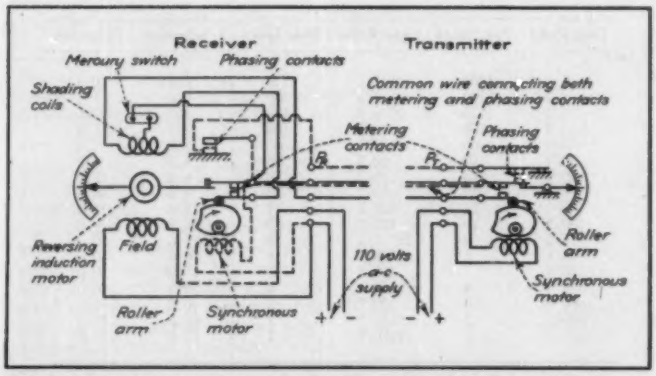


Fig. 4—Synchronous motor driven telemetering system in which the position of a cam at the receiving station is synchronized with that of a cam at the sending station.

Other Control Circuits

Other circuits illustrating the application and control of synchronous, induction, and d-c sub-miniature motors are shown in Figs. 4 to 6 inclusive. The diagram in Fig. 4 illustrates a typical synchronous motor telemetering system, this system being based on the synchronization of two similar cams, one at the transmitting and one at the receiving station. The design is based on the positioning of the receiving instrument pointer by means of impulses sent over the transmission lines. These impulses are timed in such a way as to produce intervals that are a function of the value being measured.

The transmitting element consists of a pivoted contact bar riding on the rotating cam, which is driven by the synchronous motor. A second contact bar is positioned by the primary measuring element. The length of time that the two contact bars maintain a closed circuit is dependent on the position of the measuring element. A similar rotating cam and set of contact bars are at the receiving station, the upper bar being positioned by the pointer on the receiving instrument. This receiving pointer is driven in either direction by an induction motor with two shading field coils. If the circuit of one shading coil is closed, the motor rotates in one direction; if the other coil is closed, it rotates in the opposite direction. With both coil circuits closed, no rotation takes place.

The mercury switch in the circuit is operated by the synchronous motor and is arranged to break the motor circuit before the contact points drop. This prevents arcing and insures good electrical contact at all times.

The two cams must be in exact relation to each other if the system is to work properly. This means that there must be a method of phasing the two synchronous motors when starting up. This is done by means of the phasing contacts P_s and P_r which so control the circuit of the receiving synchronous motor as to require it to rotate in phase with the transmitting motor at all times. This phasing circuit requires the use of an extra transmitting line.

The circuit in Fig. 5 represents a system whose motor speed is proportional to the deviation of the circuit from the control point. This feature is desirable since it reduces the tendency of the system to overshoot.

The potentiometer P applies an adjustable voltage to the vacuum tube grids. This being the case, it is necessary for the bridge-circuit current to exceed a certain value to energize the electronic tubes. This bias is opposed

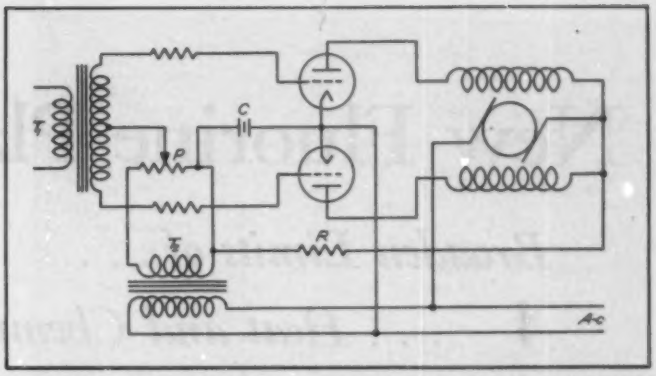


Fig. 5—Induction motor whose speed is proportional to the deviations of a bridge circuit from the control point. Rate of change in the current flow governs speed.

by a current obtained from the rotation of a split-field induction motor that develops a current with approximately the characteristics of a d-c rectified sine wave. This current is passed through a resistance, R, and gradually charges a capacitor. As the charge is built up in the capacitor, the positive charge on the grid is depressed until it falls below the critical point and the current flow to the motor stops. When this happens, the charge in the capacitor leaks off and the motor again operates.

The effect of this circuit arrangement is that the motor runs only when the current flow from the bridge circuit is increasing at a more rapid rate than the charge building up in the capacitor. As a result, the motor runs continuously while the flow is increasing or decreasing rapidly. However, when the flow is checked, the capacitor charge builds up and intermittently stops the flow of current to the motor.

Finally, Fig. 6 shows a simplified hook-up of a d-c servo-system, the motor for which is controlled from the plate circuits of a subminiature vacuum tube amplifier.

This motor has two independent high impedance field windings for reversible rotation. The armature is operated from a separate 28 volt d-c power source through series external resistance of 28.5 ohms. The magnetic circuit of the field is designed to saturate at a field current of 6 milliamperes to prevent the motor from slowing down with an increase of field current beyond 6 milliamperes.

In one operating scheme, the two field windings are connected into the two plate circuits of a push-pull amplifier. When the two plate currents are in balance, the motor is at rest. When the plate currents are unbalanced, the motor runs in a direction and at a speed depending upon the degree of unbalance.

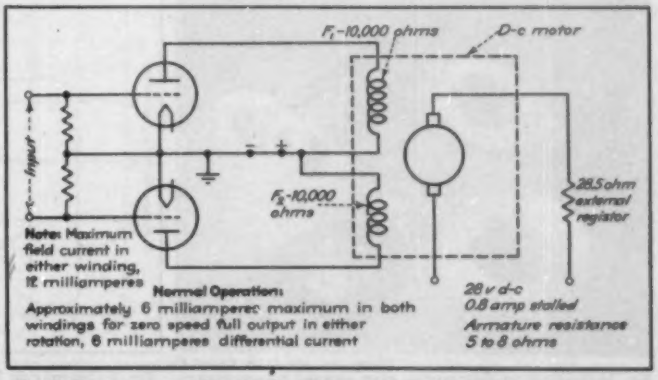

F1-10,000 ohms
D-c motor
Input
F2-10,000 ohms
28.5 ohm external resistor
Note: Maximum field current in either winding, 12 milliamperes
Normal Operation:
Approximately 6 milliamperes maximum in both windings for zero speed full output in either rotation, 6 milliamperes differential current
28 v d-c
0.8 amp stalled
Armature resistance 5 to 8 ohms

Fig. 6—D-c servo system for aircraft utilizing a lightweight precision d-c motor with two independent high impedance field windings for reversible rotation.

New Fluorine Plastics

Broaden Limits of . . .

. . . Heat and Chemical Resistance

Based on fluorinated hydrocarbons, these new polymers have the useful combination of excellent electrical properties, high heat resistance and dimensional stability in the presence of moisture and many chemicals. Since they are thermoplastic, these materials can be molded by injection and other rapid methods. Surface hardness and other properties can be varied by heat treatments.

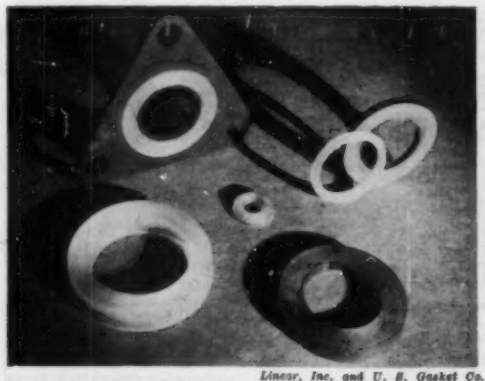
LOUIS C. RUBIN
Chemical Manufacturing Division,
The M. W. Kellogg Company

DEVELOPMENT OF POLYMERIZED FLUOROCARBONS, or the so-called "fluorine plastics," introduced a group of materials which have the physical properties desirable in a plastic, and still retain the unusually high chemical resistance of fluorine compounds. One such plastic, polytetrafluoroethylene or "Teflon," was described in an article in PRODUCT ENGINEERING (p. 154, November 1947). Another material of this family has been made available more recently; this is a high polymer of trifluorochloroethylene, known commercially as "Kel-F."

As currently produced, Kel-F plastic is an exceptionally stable, high temperature, non-inflammable thermoplastic that can be molded by established techniques. In its natural state it is colorless, but it can be blended with solid fillers and coloring agents.

CHEMICAL RESISTANCE. Kel-F is extremely inert chemically. No effect has been observed after prolonged exposure to concentrated sulfuric, hydrofluoric and hydrochloric acids, or to strong caustic, to fuming nitric acid, aqua ragia and other vigorous oxidizing materials. Highly halogenated organic solvents and, to a lesser extent, aromatic solvents tend to swell the fully "quenched" (see later section on heat treating) polymer at elevated temperatures. However, the swelling is not solution or chemical reaction, but is a plasticizing action which gives a softer, more flexible material.

PHYSICAL PROPERTIES. The general and mechanical properties of Kel-F are



Linear, Inc. and U. S. Gasket Co.

Fig. 1—Resistant to deformation when exposed to temperature extremes and chemicals, these products include molded O-ring, U and V packings, two envelope-type gaskets and valve seat.

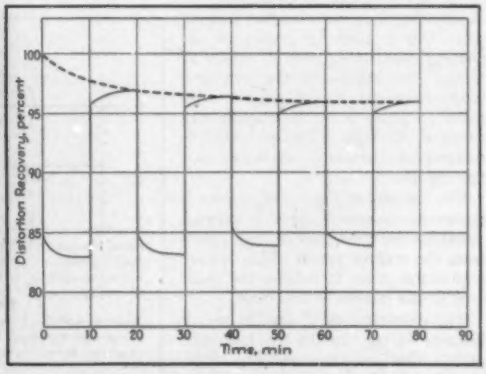


Fig. 2—Intermittent loading to deform (compression) of fluorine polymer shows substantially complete recovery—good "elastic memory"—on removal of the load.

shown in Table I. The zero water absorption and the extremely low water vapor transmission for thin sheets are unique properties for plastic materials. This material also has exceptional resistance to "wetting" (surface absorption) by water. It is thus a useful material in high humidity or tropical atmospheres. These properties are independent of any processing or heat treatments.

Tensile strength in unoriented sections of this material is about 5,700 psi; in oriented fibers this increases to about 30,000 psi. In addition to the properties shown in Table I, Kel-F has good resistance to thermal shock. It can be made flexible or hard, and is tough over a range from the temperature of liquid nitrogen (—320 F) to about 390 F. It is resilient, and does not show cold flow when used as a gasket material (Fig. 1). The expression "cold-flow" as applied to plastics means permanent deformation of the plastic when subjected to pressure. In this respect Kel-F deforms slightly under load, but it has a good "elastic memory." As shown in Fig. 2, when loaded sufficiently to deform, the recovery is substantially complete on removal of the load.

When produced in relatively thin sections, the polymer can be fairly transparent. Light transmission of such sections indicates possible uses as an unbreakable corrosion resistant window material. For such applications the polymer can serve as its own gasket. Fig. 3 shows transmission of infrared light from 2 to 16 micron wavelengths. Up to about 4 microns transmission is better than 80 percent; in the higher frequencies, transmission drops to below 10 percent. This indicates a possible use for thin sections.

Table I—Physical Properties

Property	Unit	Results	ASTM Test Method
Specific gravity	.....	2.1	D792-44T
Refractive index	n_D^{25}	1.43	D542-42
Thermal coefficient of linear expansion			
—80 to 20 C	in./in./C	4.5×10^{-5}	D696-44
20 to 150 C	in./in./C	7×10^{-5}	D696-44
Thermal conductivity	cal/cm²/sec/C/cm K	1.44×10^{-4} 0.418	....
Specific heat	cal/g	0.216	.....
Water absorption	percent	0.00	D570-42
Water vapor transmission			
0.002 in. sheet	g/100 sq in./24 hr	0.02	*
0.003–0.009 in. sheet		0.00	
Brittleness temperature	deg F	<—120	D746-44T
Outdoor aging, one year	.....	No detectable change	
Rockwell hardness	R scale	111–115	D785-48T
Durometer hardness	D scale	80	D676-47T
	A scale	>100	D675-47T
Impact strength, Izod, notched, 77 F	ft-lb/in. of notch	3.62	D256-47T
Tensile strength**	psi, 77 F	5,730	D638-46T
Yield strength, 0.2 percent offset	psi, 77 F	3,640	D638-46T
Flexural strength	psi, 77 F	8,260	D790-45T
Compressive strength	psi, 77 F	32,000–80,000	D695-44T
Modulus of elasticity			
Tensile	psi, 77 F	226,000	D638-46T
Flexural	psi, 77 F	182,500	D790-45T
Compressive	psi, 77 F	191,000	D695-44T
Abrasion resistance			
59 9946 g heat-treated	loss/g/1,000 cycles	0.0048	Fed. Spec. L-P-406-a, meth. 1091
57 3753 g quenched	loss/g/1,000 cycles	0.0175	

* General Foods moisture vapor transmission test at 100 F and 95 percent relative humidity.

** Tensile strength in oriented film as high as 30,000 psi.

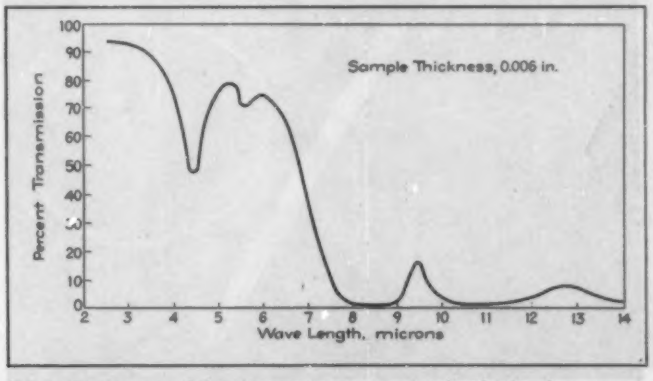


Fig. 3—Transparency of thin sheets to longer wave lengths of infrared spectrum is sufficient for use as a shock-resistant infrared window material on special instruments, where corrosion, temperature extremes and electrical forces might also be involved.

ELECTRICAL PROPERTIES. Table II shows typical electrical properties of Kel-F. Its excellent dielectric strength, arc resistance and general electrical resistance, combined with high temperature and good mechanical properties, make this a promising material for the electrical industry. The dielectric constant and power factor, while not the "best" in the high frequency range, are sufficiently good to fill a definite need in the high frequency and general cable field. The dielectric constant is in the range of the best available materials, as shown in Fig. 4. Fig. 5 shows how the dissipation factor varies with frequency and temperature.

HEAT RESISTANCE. ASTM heat distortion temperatures are not particularly indicative of suitable operating temperatures for fluorine plastics.

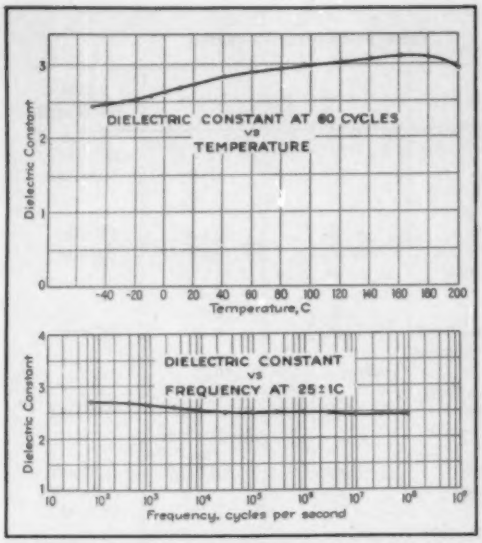


Fig. 4—Dielectric constant is in the range of the best available electrical insulating materials used at these temperatures and frequencies. These properties have extended use of the material into the manufacture of electrical and electronic devices.

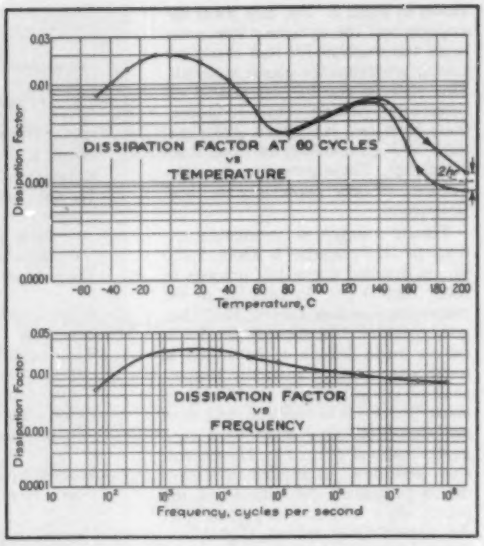


Fig. 5—Variation of dissipation factor with temperature and frequency indicate its applicability at high temperatures and high frequencies. In temperature test, material was held for 2 hr at 200 C, and dissipation measured as temperature was reduced.

Kel-F molded sections have proven satisfactory at temperatures up to 390 F, in continuous service.

In thermoplastic materials, molecular weight is directly related to degree of polymerization, which in turn is a measure of rigidity and heat resistance. If, through sustained exposure to high temperatures, a plastic material deteriorates and loses its load-carrying ability, this shows up as a severe drop in molecular weight. However, because of its chemical inertness, it is impossible to measure the molecular weight of Kel-F.

An arbitrary method of indicating the same quality—the degradation of materials after continuous exposure to high temperature—consists of determining "No Strength Temperature," by measuring the temperature at which a notched test strip breaks under a slight tensile load. The test strip is a compression molded notched piece 2 x $\frac{1}{2}$ x $\frac{1}{8}$ in., with the plastic below the notch weighing 0.5 gram (including an added weight). Temperatures are brought rapidly to 430 F and then raised still further at the rate of about 3 F per min until the test strip parts at the notch. The temperature at which this happens is the "No Strength Temperature" (NST). Differences of 10F are considered significant.

Plastics with NST values lower than 430 F, while satisfactory for low and moderately high temperature uses, tend to crystallize and become brittle above 300 F. The higher the molecular weight, and consequently the higher the NST, the more difficult it is to get brittleness resulting from exposure to high temperature. In general, materials with NST of 500 F and higher are safe for high temperature engineering uses. The two main commercial formulations of Kel-F have NST values of 270 C (518 F) and 300 C (572 F); based on these, "grade numbers" of 270 and 300 have been assigned to the two types of compounds.

HEAT TREATING. Physical properties of the molded plastic can be varied by specific thermal treatments.

Products molded from Kel-F can be varied from an amorphous material which is relatively transparent, soft, tough, and flexible, to a crystalline material which is milky in appearance, hard, and resistant to distortion. De-

Fig. 6—Products extruded from Kel-F include (left to right): Coated 0.30 in. wall hook up wire, $\frac{1}{4}$ in. rod, and $\frac{1}{2}$ in. rod.

gree of crystallization is determined primarily by the rapidity with which the molded part is cooled (quenched) through a temperature range of about 400-300 F from its molding temperature.

A rapidly quenched piece gives a transparent, flexible section of moderate surface hardness. If this same section is slow cooled from above the transition temperature (213 C or 415 F) it becomes translucent, much less flexible and appreciably harder. Intermediate properties result if the molded item is held just below the transition temperature for a time. Typical data for heat treating, Table III, show an increase in surface hardness of 8 to 9 (after quenching) on the Shore scale.

The lower the NST or molecular weight of the polymer being heat treated, the more rapid the crystallization and the lower the temperature required during heat treatment. For example, quenched low-molecular-weight film with an NST of 435 F, although flexible and useful as film at ordinary temperatures, will crystallize fairly rapidly at a temperature of 350 F and become brittle. Quenched film with an NST of 525 F will show comparatively little change on heating to the same temperature for prolonged periods. Even if crystallized by heating at higher temperatures, it still retains its toughness.

Because of the insulating properties of the polymer, complete quenching is possible only with relatively thin cross sections. The quenching of internal parts of thicker sections that are cooled rapidly varies with distance from the surface. Quenched $\frac{1}{16}$ in. sheet is almost perfectly transparent, but $\frac{1}{8}$ in. sheet has a slight blue haze, caused by light scattering of crystallites. This becomes more apparent in thicker sections.

In addition to increasing hardness, heat treating can have a beneficial effect on dimensional stability. Annealing for 24 hr at 255 F is adequate to assure retention of dimensions.

The effect of organic solvents on Kel-F can also be varied by heat treatment. For example, although fully quenched material can be swollen or "plasticized" by halogenated organic liquids, heat treated or crystallized material is very much less affected.

PLASTICIZING. Since Kel-F can be swelled by highly halogenated organic materials, the usual plasticizer compounds incorporated in other thermoplastics are not suitable. However, low molecular weight polymers of trifluorochloroethylene in the form of oils or waxes (available as other grades of

Table II—Electrical Properties

Test	Unit	Results	ASTM Test Method
Dielectric strength	step by step, 1/8 in., v/mil	390	D149-44
	step by step, 0.030 in., v/mil	1,200	D149-44
	step by step, 0.005 in., v/mil	5,000	.....
Volume resistivity (50 percent R. H. and 25c)	ohm-cm	1.2×10^{18}	D257-46
Arc resistance	sec	>360	D495-42

Table III—Effect of Heat Treating

Material* Grade No.	Shore Hardness (Diamond Hammer)		
	Initial (Quenched)	Heat Treatment	
		24 hr 385 F	48 hr 385 F
270	64	73	72
300	64	72	70

* Samples 2 x 4 x 1/16 in. compression molded.

Table IV—Effect of Plasticizer on Hardness

(Grade 300 quenched)

Percent Plasticizer	Hardness Test Method		
	Shore	Durometer A	Durometer D
0	68	.....	77
8.3	63	95	65
22.8	34	96	55
24.5	30	96	51

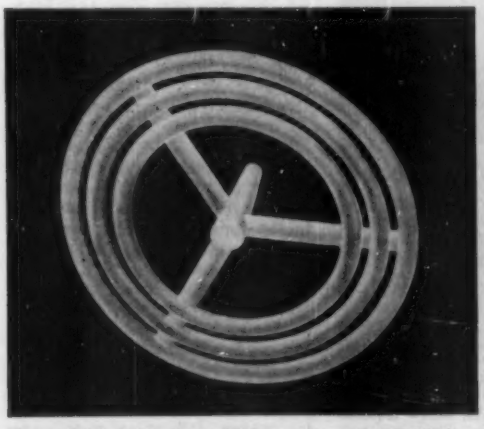


Fig. 7—Typical injection molded part shows that Kel-F flows readily to form a well-knit section of uniform properties.

Visking Corporation

Fig. 8—Film of 0.005 in. wall thickness is extruded as 2$\frac{1}{2}$ in. flat tubing. Film of this type has a tensile strength of 6,500 psi.

Kel-F) have some lubricating properties and exhibit the same chemical inertness as Kel F. These materials can be incorporated in Kel-F molding compounds as plasticizers. Table IV presents data on hardness versus percent of plasticizer used, by several methods of measurement. The hardness range shown, a decrease over that obtainable by heat treatment (rapid quenching) of unplasticized material, is advantageous for many uses.

Molding and Fabrication

Both grades of Kel-F are currently produced in the form of low density molding powder and high density ⅛ in. granules. The two forms differ primarily in bulk density, the former being about 19 lb per cu ft and the latter about 60 lb per cu ft. Kel-F can be molded by compression, injection, transfer and extrusion procedures. Molding temperatures are appreciably higher than for most other thermoplastic materials, being in the range of 500 to 600 F, depending on the particular operation. For this reason, care must be taken to avoid contamination with other thermoplastics, which will decompose at these high temperatures and appear as dark areas in the piece.

Uniform heating is essential for successful molding of Kel-F; electrical heating and adequate thermocouple temperature measurement are therefore indicated. In compression molding, 1,000 psi pressure is used; grade 300 can be pressed between 480 and 590 F, grade 270 between 465 and 535 F. Pressing time varies with thickness of the piece:

Thickness, in.	Pressing Time, min	
	Grade 300	Grade 270
0.2	10	7
0.4	25	20
0.6	40	28
0.8	55	40
1.0	65	50

These values were obtained by molding 2½ in. dia disks of both types at 480 F. However, as the pressing temperature is raised, the time required decreases. For example, grade 300 material can be pressed at 570 F in half the time.

These materials are especially well suited to production by transfer molding, a variation of compression molding. This method is applicable for parts of large section, or parts containing delicate metallic inserts, such as electrical components. Molding temperatures of 500 to 600 F are used in this method.

Compression molded sheets can be quenched, slow cooled, pigmented, or laminated with stainless steel gauze, to produce a variety of transparent or opaque effects. Thinner sections, up to ½ in. thick, can be formed between highly polished stainless steel or ferrotype sheets without a mold, because of the relatively high melt viscosity of the material at molding temperatures.

Both types can be injection molded for high volume production of relatively small, close tolerance parts. Molding pressures vary from 5,000 to 20,000 psi. Molding temperatures vary from 480 to 560 F for grade 270, and from 540 to 620 F for the 300 grade.

The typical injection molded part in Fig. 7, shows that the material flows readily under pressure through gates and sprues to easily fill the mold and form a well-knit section. Injection molding cycles for Kel-F are appreciably shorter than for many other thermoplastic materials. When a direct comparison was made in the same machine and mold, a 60-sec cycle was required for ethyl cellulose, while with Kel-F a 39-sec cycle was satisfactory.

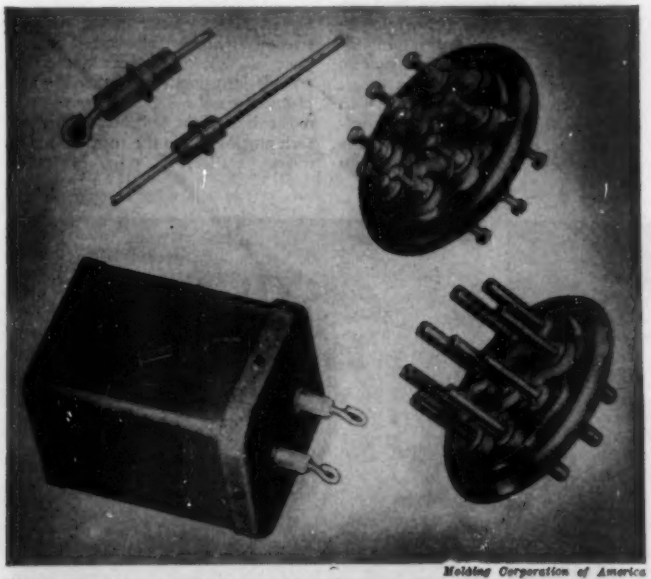
Conventional extrusion machines can be used to extrude these plastics if they are capable of reaching the required temperatures. Die temperatures vary from 550 to 650 F. Such products as extruded rod and hook-up wire can be extruded at good production rates. Extruded thin wall tubing and film, shown in Fig. 8, can be produced in almost any desired diameter, and from 2 to 10 mils in wall thickness.

Kel-F sections can readily be heat-sealed with heat and some pressure.

MACHINING. Kel-F can be easily machined with ordinary machine tools, and does not tend to chip or crack. Sheets up to about ½ in. can be readily punched or sheared.

Applications

Properties of Kel-F suggest applications in the electrical field, where resistance to higher temperatures and good electrical characteristics (Fig. 9) are a decided economic advantage. Other electrical uses could take advantage of the non-wetting property and the extreme chemical inertness. The chemical inertness, dimensional stability over a wide temperature range, and good mechanical properties make Kel-F valuable material for the chemical industry, where it has already proven itself as an excellent material for gaskets and valve parts under highly corrosive conditions.



Molding Corporation of America

Fig. 9—Transformer terminals are made resistant to thermal shock cycling, humidity, salt water immersion, and high operating temperatures by hermetical sealing with Kel-F. Several of these terminals operate at 15 amp and 2,000 volts, with a required insulation resistance of 1 million megohms; these characteristics must be maintained over a —100 to 200 C temperature range.

Saving Drafting Time With

PHOTOGRAPHY

An experimental department set up by the Ingersoll-Rand Company at their Phillipsburg plant points the way to a complete, workable, step-by-step procedure for getting better drafting results in less time, with less hand work, and without special, high-priced equipment.

E. H. MARKLEY
Engineer-in-Charge
Condenser Engineering Dept.
Ingersoll-Rand Company

UNTIL RECENTLY, photographic reproductions have had little use in most drafting rooms. Time honored and costly hand work has been the rule. The development of new materials, new processes, and new methods has radically altered this situation, so that today it is possible to establish a new approach to drafting, based on the use of photographic reproductions to eliminate laborious handwork.

Any approach to a fast, cheap drawing process automatically rules out ink tracings. The problem, then, is that of reproducing original pencil drawings with prints of the highest quality, produced in the shortest possible time, and at the least cost consistent with the maintenance of such quality.

Characteristics of the Photographic Materials Used

In general, two characteristics are necessary for any reproduction method: (1) permanence, since many drawings are filed only in reproduced form; and (2) line quality, since sharply defined, high intensity lines insure legible prints. Both requirements are met by existing photographic materials.

The long life of a photograph, properly processed, is an established fact. Equally well established, though perhaps less well known, is the ability of the silver emulsions used in photography to heighten contrast, providing dense black lines on a clear, white background. The line density of a photographic print, properly exposed, is invariably greater than the line density of the original pencil drawing from which it was made.

Both these facts indicate the choice of photographic reproduction materials, and especially a new photographic paper, known as "Autopositive Paper," a patented product of Eastman Kodak Company. Unlike conventional photographic papers, Autopositive paper produces a positive copy directly from an original pencil drawing, without a negative. Obvious savings in time and material can be effected through this one-step method, as compared with familiar negative-positive methods. At the same time, the new paper offers an escape from darkroom processing, since it can be handled in room light. "Autopositive film" and "Autopositive cloth" like the paper, are also one-step materials differing only in the base on which the silver emulsion is coated.

Putting Reproductions to Work

In making all types of reproductions, the quality of the original drawing is paramount and the basic principles of good drafting increasingly important. "Paint brush" and fine lines must be avoided. Letters and numbers should be kept open. Circles and compass lines should be of equal density to straight lines. In general, a 2H pencil will give a line of adequate density, with an H pencil used for arcs and similar lines where the normal tendency is to exert less pressure. By training draftsmen to follow these practices and by selecting an open type face for standard drawing forms on good vellum, originals can be made which yield reproductions of optimum quality.

Given such originals, a pencil drawing on vellum is quickly converted to the equivalent of an ink drawing on cloth by photographic means. Autopositive cloth is placed in contact with the original drawing and exposed for a matter of seconds to a high intensity light source. This may be done on either conventional blueprint or diazo equipment, or on a conventional vacuum frame "souped up" by replacing the standard tungsten lamps with photofloods. Where this latter practice is followed, the photocopier should be equipped with an electric blower to provide the adequate cooling necessary because of the photofloods.

In exposure, transparent yellow sheeting is used as a filter between the light source and the original drawing. The drawing is placed on the sheeting and the Autopositive cloth is positioned on top of the drawing. After exposure, the cloth is given conventional photographic processing, dried, and is ready for use.

The resulting positive reproduction may be either right-reading or reverse reading, depending on whether or not the pencil lines of the original were in direct contact with the silver emulsion of the photographic cloth. Where a right-reading reproduction is required, the drawing is placed face towards the light source with its back to the emulsion; where a reverse-reading cloth may be used, the drawing is placed face towards the cloth. Both types of prints have their advantages. Reverse-reading prints offer greater sharpness since there is less diffusion in printing, hold weak lines somewhat better, and offer sharper blueprints, since line-to-line contact is maintained in the blueprinting process. Against this is offset the legibility of the right-reading reproduction and the ease of making changes and alterations on the face of

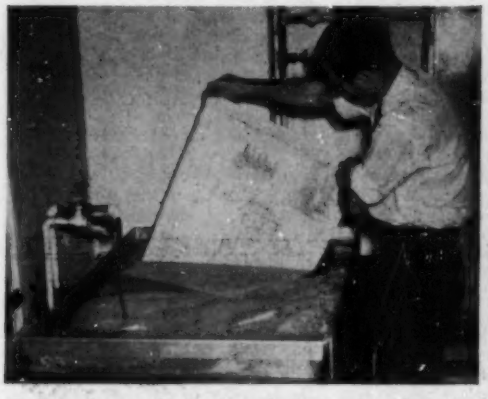
A Step-by-Step Photographic Process for Making Drawing Changes

1 First step in making drawing changes. Unwanted, or out of date sections of drawing are simply sliced out of photographic reproduction with a razor. . . .

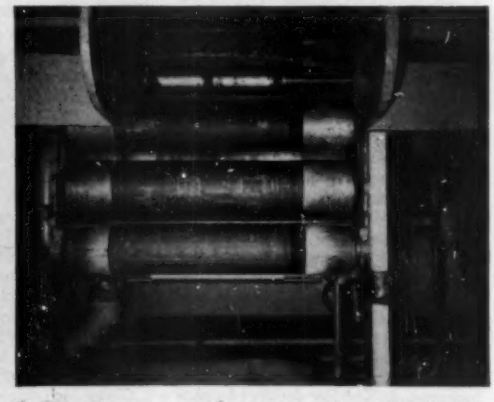
2 Next, the "edited" reproduction is used to print a second reproduction. Original cut-out sections appear as perfectly white blanks on the second print. . . .

3 Then, the required changes are drawn in with a hard, sharp pencil or a standard overlay is taped into place, to fill blank spaces and connect with existing lines. . . .

4 After all changes have been made, the revised reproduction is used to make a positive photographic copy on cloth or paper with a single exposure. No negative required. . . .



5 Now the reproduction is ready for use in making shop copies and for permanent file, serving as an original drawing. Handwork has been kept to a minimum. . . .



6 Blueprints are now made, as usual, and are highly legible, with clean, sharp lines on a contrasting background. The completed reproduction can now be filed. . . .

the cloth, rather than on its back.

In general, all new vellum drawings should be reproduced on cloth in this way, since cloth provides a medium which stands up under great abuse. At the same time, Autopositive-cloth reproductions are "to scale." Stretch and distortion are negligible in the one-step process since this by-passes the paper negative. And it is in the negative step that distortion originates when making cloth reproductions by conventional negative-positive methods.

The printing process described above is used not only for cloth reproductions, but also for making reproductions on either paper or film. In some cases, as when a drawing is likely to see little future use, a paper reproduction may be acceptable as a file copy. However, paper reproductions have many other diverse applications and lend themselves for use as intermediates in a number of ways.

Restoring Damaged Drawings

One of the most important uses for such intermediates is the restoration of worn, stained or damaged drawings. Often an old and abused drawing from which no acceptable blueprint may be made, can be reclaimed by the use of Autopositive intermediates. Where the drawing is not too badly damaged, the high contrast of the silver emulsion may be sufficient to clean up the background and increase the general line density to a point where acceptable blueprints can be made directly from the reproduced print, without handwork.

With more badly damaged drawings, however, additional steps may be necessary. One of the most successful techniques calls for the making of a reverse-reading Autopositive from the damaged original. Major unwanted marks caused by dirt, tears, or cracks may be removed by cutting out the affected sections with a razor blade. Minor unwanted sections are removed by common eradicators. This "edited" reproduction is then used to make a second Autopositive and, where necessary, lines or lettering may be touched up with pencil on this latter, right-reading print. Since line-to-line contact has been maintained in going from original to reverse-reading and back to right-reading, the finished intermediate shows little line spread and may be reproduced on cloth or used to make blue prints. Exceptionally poor drawings may be restored in this manner with a fraction of the handwork involved in retracing a damaged original.

The Overlay Method

Where assemblies are made from standard components, the use of stock form overlays can greatly extend the usefulness of combination drawings. A typical example of such components, used in condensers, are water boxes and condenser shells. These are made in a number of sizes and may be combined in different ways to meet the specifications of a given job. Overlays of water boxes of the desired size may be positioned on drawing paper as desired, together with an overlay of the shell to be used. The necessary connections and details may be added in pencil, producing a finished drawing in a fraction of the time required to draft the assembly manually.

Similar techniques are used in making combination drawings—drawings made part manually and part photographically. With this technique, new views and sections may be added to a drawing and changes may be made without the need for redrawing or retracing the unaffected sections. This is a proven method of saving drawing time which may be applied either in changing an existing drawing or in drafting an assembly to be made up from standard components.

An example of this technique is afforded by assuming an existing drawing on which a 6-inch flange is to be replaced by an 8-inch flange and a sectional rib detail is to be added. A reverse-reading paper reproduction is made of the existing drawing and the flange details of the drawings are cut out and removed. Concurrently, the rib

7 Final photographic step is the microfilm camera. All drawings should be microfilmed, and the film rolls should be stored in fireproof vaults for safety. . .

8 Another time saver is the overlay process. Complete drawings are made by piecing together standard component drawings, and then making cloth or paper reproductions.

detail is reproduced on Autopositive film, and this transparent reproduction is taped in place with transparent tape, as an overlay on the print. A right-reading print, including the rib, is then made from the first intermediate and, since the cut-out areas are blank, the 8-inch flange is now pencilled in, joining with the photographic lines as required. This is now a finished drawing from which blueprints may be made in which the pencil lines cannot be distinguished from the photographic lines. Nor can the overlay outline be distinguished in the print.

Blueprints From Blueprints

Photographic methods are also used in making reproductions from blueprints where blueprints are the only copy available for use. Since a blueprint is in itself a negative, conventional contact photocopying paper is used to produce a positive of it in a single step. This may be retouched if necessary and from it a cloth reproduction is made, again using Autopositive cloth.

Thus, it can be seen that these new techniques have several advantages over conventional reproductive methods. The time savings afforded by photographic reproductions, however, cannot be estimated easily. Depending upon the complexity of the drawings involved, they range from 10 to 75 percent. It is sufficient to point out that months of experimental production have proved that great reductions in drafting time can be made.

However, these methods have brought additional benefits in improving the quality of final shop prints and in lengthening the life of the drawings. In cases where many prints are required, it is impractical to allow an original drawing to be submitted to the wear of print making. Reproductions on cloth or paper are used as printing masters and the original drawing remains in the file except when changes are needed. As a result, originals always remain in excellent preservation, while blueprints from high-contrast reproductions offer greater contrast and legibility than blueprints made directly from the original drawings themselves.

Trick Metals May Improve Strength of Steels

SILVER RODS THAT BEND like lead but cannot be unbent. Metal wires that can be stretched as easily as a piece of taffy—once, but not a second time. Such are the characteristics of trick metals developed by Professor E. N. daC. Andrade, world authority on metallurgy, at London's University College.

The ordinary piece of metal is made up of a myriad of microscopic crystals. By contrast, the rods that bend and wires that stretch are single crystals several inches in length. It is this monocrystalline structure of Professor Andrade's metals that gives them their special properties.

Of what practical value is this work with metals that exist only in specialized laboratories? It is well known that even the toughest steel producible is only 1/40 as strong as it theoretically could be. "Where so many of the dreams of inventors are clearly impossible on simple grounds of energy and related fundamental considerations, gigantic advances are here, at any rate, not inherently ruled out," Professor Andrade declares.

A one-half-inch single-crystal wire can be stretched under loads of 2 to 20 lb, depending on the metal. But once the wire is pulled, or the rod bent, the metal undergoes a strange toughening. A single-crystal copper wire can easily be pulled to twice its original length; it then requires 80 times as much force to stretch it further. X-ray analysis indicates the reason for this is that stretching destroys the single crystal structure of the metal.

Another unusual characteristic of single crystal metals is that, regardless of the direction of the pull, they insist on stretching in directions of their own choice. Nor does the wire stretch uniformly. Rather it elongates in spurts along certain very definite glide planes.

The result of this stretching action is a peculiar flattening of the wire, accompanied by curious steplike ridges, as if the crystal had moved in layers. These steps are slip-bands and can clearly be seen with the naked eye. The distance between the bands varies with different metals and with temperature. Sometimes a single crystal will exhibit several slip planes at angles to each other and frequently twinning occurs, with two sets of bands that are mirror images.

The softness and gliding properties of single crystal wires Professor Andrade explains on the basis of imperfections in the surface layers of atoms, ultra-microscopic "cracks" in the atomic "skin" of the crystal. Thus, a coating of oxide only 20 atoms thick will increase by 50 percent the force required to stretch a 0.5 millimeter wire, while thicker films will double the stress required. Also, bombarding a wire with alpha particles while it is being stretched, markedly increases the rate of flow of single-crystal cadmium in the early stages when fresh glide planes are being formed. Since alpha particles have no penetrating power, this can only be a surface effect.

It is possible that internal flaws may play a part in this crystal behavior, but so far surface defects are the only ones whose effect has been definitely proved in the case of metals.

Analogous deductions can be made from the experimental weakness of nonmetals like glass, quartz and rock salt as compared with their theoretical strengths. In each of these cases, it has been shown that the weakness lies in minute cracks in their surfaces, cracks which can be made visible by exposing them to sodium vapor. In the case of sheet mica, the surface of which is remarkably free of flaws except at the edges, it has been shown that the strength of such sheets is ten times greater when the stress is kept solely on the perfect surface than when it extends to the imperfect edges.

To make his single crystals, Professor Andrade encloses an ordinary polycrystalline wire in a glass tube in which it fits loosely and from which all the air has been evacuated. He then runs a traveling furnace slowly over the tube at a rate of about one half to one inch per hour. The wire melts locally and then resolidifies as a crystal.

One lesson learned from the study of the single crystals is that, because of atomic flaws, the individual metal crystals are exceedingly weak. The greater strength of every-day metals lies in their haphazard polycrystalline structure, with the glide-planes and glide-directions of the crystals oriented at random. Thus, each crystal is hemmed in by other crystals that will not readily "give" in the same direction or plane in which it moves most easily. This is much like the principle of the girder, in which the planes of several sheets of metal are fixed at right angles to each other.

Professor Andrade believes his experimental results point out two tasks for the practical metallurgist: (1) To see if the atomic flaws in metal surfaces can be eliminated; and (2) if not, to see how the polycrystalline nature of metals can be increased.

Dimensioning Involute Gears On Manufacturing Drawings

Simplified method of dimensioning involute gears on manufacturing drawings. Basic gear dimensions are discussed and a simple data form proposed that describes the gear completely without superfluous interdependent theoretical dimensions.

SYDNEY L. TERRY

THE GEOMETRY of conventional involute gears operating on parallel shafts is extremely simple. Yet principally because of the inept method of describing gears that has grown up through the years, gear drawings are difficult to interpret. Drafting standards differ widely, even among the large gear manufacturers.

In addition to the gear drawing, tool companies asked to supply tools to manufacture a gear frequently require at least a drawing of the mating gear and the mounting center distance. They know from experience that all this information, and probably more, will be required to reconcile the drawing data with the conditions required for proper mating of the teeth.

If a gear is described as simply as possible, the description will suggest some fundamental changes in gear tooth data that would

1. Avoid ambiguity in gear data.
2. Avoid repetition of gear dimensions, omitting data directly dependent on other data given elsewhere.
3. Permit a gear to be made correctly from its drawing alone.

When describing a gear, the correct starting point is the external dimensions used in the manufacture of the blank. The two blank dimensions that affect the teeth are the face width F, and the outside diameter D_o. As a rule, these dimensions with their required tolerances are given on the body of the drawing.

The most obvious tooth dimension is the number of teeth on the gear. The most fundamental dimension, as far as the gear tooth profiles are concerned, is the base pitch. These two dimensions, without tolerance, head the list of required data. They determine completely and definitely the pitch, the base circle diameter, and the contour of the active tooth profiles of the gear described.

The base circle circumference is simply the base pitch multiplied by the number of teeth. There is only one base pitch for a given gear, and mating gears on parallel shafts must have equal base pitches. In contrast, a given gear may have any number of circular pitches, since the circular pitch is based on some gear diameter and varies for different diameters.

Specification of circular pitch is often ambiguous, because the diameter for which the circular pitch applies is not clearly designated. Circular pitch may be calculated from any one of several different operating pitch diameters, from a generating pitch diameter, or from a nominal generating pitch diameter. Cases have even been found where the diameters for measuring circular pitch were determined by calculating the tangent diameters of two mating gears at which their circular tooth thicknesses were equal. No such confusion can exist if base pitch is used, for each gear has only one base pitch and only one base circle.

Either base circle diameter D_b, or base pitch P_b, should be specified together with the number of teeth N. Both should not be given, since they are directly dependent on one another according to the relationship

$$D_b = p_b N/\pi \qquad (1)$$

Of the two, the base pitch is to be preferred because it may be measured directly on the gear. Sometimes five place dimensions may be necessary for the base pitch specification to give sufficient accuracy for calculations. No diametral pitches need be given. They do not add to the information alread given by the base pitch and the number of teeth. At best, the diametral pitch adds nothing to the information already given. At worst, the diametral pitch may confuse the data because the diameter for which the diametral pitch applies is not clearly designated.

The base circle diameter D_b completely determines the working portion of the tooth profiles, which are involutes of that circle. The number of teeth determines the angular spacing of these profiles. The outer limit of the teeth is controlled by the outer diameter D_o, given on the body of the gear drawing. The inner boundary of the teeth is best given by the whole depth h_t. If limits on the root diameter are desired for some special reason, the whole depth should be omitted, and the root diameter D_r given with the desired tolerances.

The only remaining basic dimension controlling the tooth size and shape is the tooth thickness. The tooth thickness varies, of course, depending on the diameter at which it is measured. Since the base circle diameter is usually less than the root diameter and always below the active profile of the tooth, it is not a satisfactory diameter for measuring tooth thickness. The outside diameter is likewise unsatisfactory because it varies quite independently of tooth thickness tolerance, causing a variation in thickness measurement. Accordingly, tooth circular thickness t should be specified at a given diameter D_t. The tooth circular thickness should be given with a tolerance, but the diameter at which the thickness is measured should be given as a flat dimension. For automotive gears the tolerance on tooth circular thickness is usually from 0.001 to 0.003 in. total allowable thickness variation.

Tooth circular thickness in the plane of rotation is basic to the action of the gear, and provides the simplest and best starting point for calculations. For these reasons, tooth circular thick-

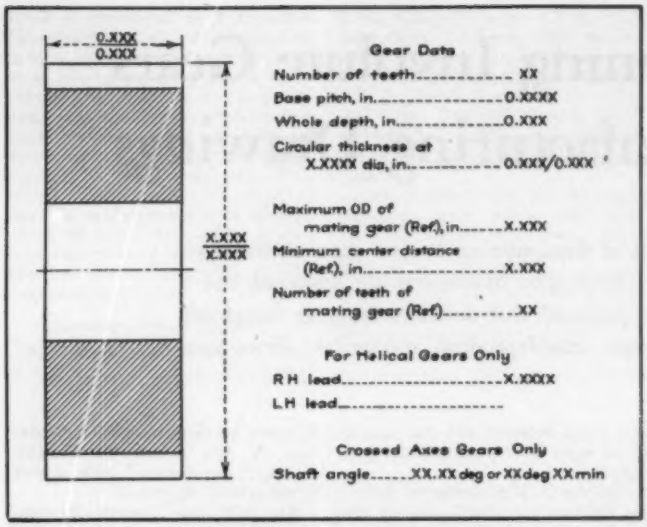


Fig. 1—Proposed method of dimensioning involute gears. Backlash, if specified, should be on assembly drawing. Circular thickness is always given in the pane of rotation for consistency. Chordal thickness in the rotation and normal planes is readily calculated from the circular thickness. Other data can be readily calculated.

ness is preferred to chordal thickness. The difference between chordal thickness t_c and circular thickness t is easily calculated by the approximation

$$t_c = t - \frac{t^3}{6D^2} \qquad (2)$$

Giving the tooth circular thickness together with the diameter at which it obtains establishes definitely the thickness intended by the maker of the drawing. Measurements over balls or rolls can be readily calculated from this thickness tolerance, and may be given as reference dimensions on the body of the gear drawing.

These six dimensions, two of which are on the body of the gear, describe the active portion of the gear tooth completely in its plane of rotation. If the gear is helical, only one more dimension is required, the lead l. Lead is the axial advance of a tooth in inches for one full revolution of the gear. The lead is the same for any point on the tooth profile; that is why it can be called a basic dimension. Helix angle, on the other hand, varies for each diameter of the gear. Thus helix angle ψ should not be included on the drawing; it can be readily calculated if desired for any diameter D_a from the relationship

$$\tan \psi_a = \pi D_a / L$$

There remains only the description of the fillet, or non-involute portion of the gear profile. The best way to tell the tool maker what is required for this portion of the profile is to give the number of teeth in the mating gear, the maximum outside diameter of the mating gear, and the minimum center distance in the final assembly.

These reference dimensions will enable the tool maker to design hobs, shaper cutters, shaving tools and so on as required, to give sufficient clearance with the tip of the mating gear and still maintain optimum tool life.

If desired for stress reasons, a minimum fillet radius may be specified. A full radius at the tip of a straight-sided generating tool of the proper whole depth and thickness gives a suitable minimum radius specification provided that the cutter does not undercut any useful involute profile, and provided no running fillet interference with the mating gear occurs. No large fillet radius should be specified without an accurate enlarged gear tooth layout.

The data listed complete the description of the gear. From these data, the gear is definitely and completely described. No superfluous interdependent theoretical dimensions are thrown in to confuse the layman and to confound the experts.

Gears operating on crossed axes may be true helical gears and may be fully described in the same way as helical gears operating on parallel axes. The base pitch of two gears operating on crossed axes, however, need not be the same. Action is correct only if the normal base pitch of the two gears, obtained by multiplying the base pitch by the cosine of the helix angle at the base circle, is equal for the two gears. Such gears generally have little capacity, but are often used for oil pump, distributor, and governor drives, as well as for the shaving method of finishing gears. For correct action of crossed axes gears, the normal base pitch p_{nb} of both gears must be equal.

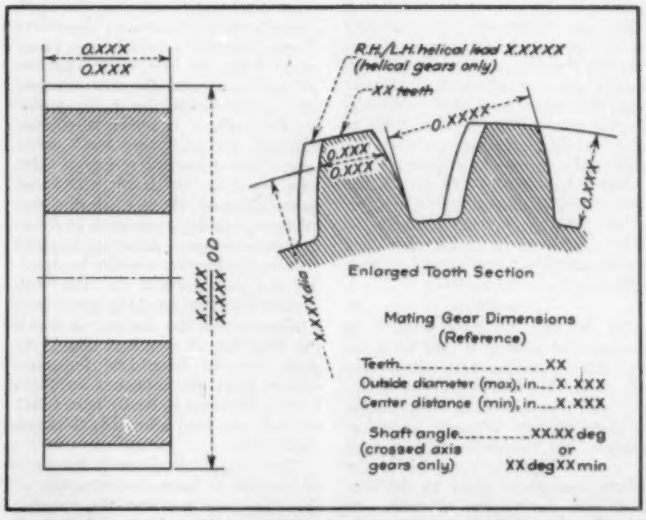


Fig. 2—Alternate method of dimensioning involute gears in which an enlarged tooth section is shown. All needed data can be specified on an enlarged tooth section.

The normal base pitch can be obtained from the following relationships:

$$\tan \psi_b = \pi D_b / l$$
$$p_{nb} = p_b \cos \psi_b \qquad (4)$$

If crossed axes gears are made with the same hob, they will automatically have the same normal base pitch, and so will transmit uniform motion at some shaft angle, regardless of the leads of the two gears. Care must be taken, of course, to see that the gears are not self locking. In general, to operate at maximum efficiency, crossed axes helical gears should have helix angles of the same hand and as nearly equal as is practicable.

It may be noted that no pressure angle is given. Pressure angle is another of the conventional gear dimensions that varies with the diameter with which it is associated. To describe correctly the pitch of a gear, pressure angle and circular or diametral pitch must be associated with the same diameter. Unfortunately this fact is sometimes overlooked by the designer when supplying gear tooth data. He knows what the base pitch is for the gears he has designed, but unless his pressure angle and his circular and diametral pitch dimensions are referred to the same diameter, he has not specified the gear he wants.

The diameter usually referred to is the pitch diameter. A given gear may have an infinite number of pitch diameters. It may be generated on one pitch diameter, called the generating diameter; and it may operate on one or more different operating pitch diameters with its mating gears.

Since "dropping a tooth from the normal blank", using "spread centers", and cutting gears on oversize and undersize blanks have become quite common, a multiplicity of pitch diameters is found to be also quite common. Such names as generating pitch diameter, nominal pitch diameter, operating pitch diameter, and rolling pitch diameter must therefore be used.

Since a gear may have any number of pitch diameters, the problem in reading the drawing is to determine which of the given diameters has been used to determine circular pitch, circular thickness and pressure angle. If more than one of the diameters has been used to calculate other dependent dimensions, the problem of divining the intentions of the designer becomes very complex.

In Fig. 1 is shown a proposed data form that removes all of these difficulties. By discarding the outmoded nomenclature, the specification simplifies the more advanced forms of gear design. Standard or existing cutters, of course, can be used to make long and short addendum gears, gears with a tooth dropped for the blank size given, and so on. The data form suggested clarifies such designs.

All conventional gear dimensions, including pressure angle, pitch diameter, circular pitch, and helix angle, can be readily calculated from the data given using the well known formulas. No wrong answers can be obtained from the data given. Note also that every gear dimension given in the data can be readily given a tolerance, and held to that tolerance. Such procedure is often impossible with the current system of gear dimensioning, where much of the data are interdependent.

All needed dimensions, with the exception of the reference dimensions pertaining to the mating gear, may conveniently be shown on an enlarged tooth section like that shown in Fig. 2. The number of teeth, right or left-hand lead, and the circular thickness of tooth should be so labeled for clarity, but the base pitch, whole depth, and the diameter for measuring the circular thickness of tooth are obvious from the enlarged tooth section.

Specification of the fundamental gear dimensions and the omission of unnecessary data materially simplifies the whole gear picture, and should prove desirable to engineers, tool designers, and production men alike.

Velocity of Second Sound Near Absolute Zero

FOR THE FIRST TIME, scientists have succeeded in measuring the velocity of second sound at temperatures well within one degree of absolute zero. Second sound, the unique wavelike process of heat transfer occurring only in helium II, offers a most sensitive means for investigating the unusual properties of this substance at very low temperatures—properties which in many ways seem to constitute a fourth state of matter.

When cooled to 2.19 K (the λ-point), ordinary liquid helium (He^I) undergoes a transition to He^{II} with a radical alteration of many of its properties. While in appearance a liquid, He^{II} exhibits characteristics of each of the three states of matter. In some ways it acts as though it has no viscosity, flowing, apparently without friction, through virtually vacuum-tight openings and up the side of a containing vessel at remarkable speed in seeming defiance of gravity. Its direction of flow through narrow orifices can be controlled entirely by the introduction of temperature differences. At the λ-point, the thermal conductivity of He^I increases very abruptly by a factor of three million giving an apparent value for He^{II} much greater than that of any other substance. This is because heat is propagated in He^{II} as waves of second sound, whereas in other materials heat flow is purely a diffusion phenomenon. All of these effects can be explained by the presence in He^{II} of a superfluid. Atoms of the superfluid have had their energy reduced by cooling to the point where thermal motion has ceased, yet the intermolecular forces are not great enough to produce a rigid solid. As a result, viscosity practically disappears.

The existence of thermal waves in He^{II} was predicted first by Tisza and later independently by Landau in their efforts to explain the unusual physical properties of the substance. Each of these theorists regards He^{II} as a mixture of a normal fluid, containing most of the thermal energy of the liquid, and a superfluid, but they differ in the quantity of energy attributed to the atoms of the superfluid. Landau considers the superfluid as possessing no thermal energy, whereas Tisza assigns to these atoms a small amount of heat energy.

According to both theorists, the application of heat to some part of a quantity of He^{II} upsets the equilibrium between the two fluids, resulting in a migration of the two types of atoms in opposite directions. As the superfluid is assumed to have virtually zero viscosity, no resistance to this internal convection is presented by the body of the liquid. A sustained internal vibration between the fluid components is thus possible, and this internal convection type of wave propagation constitutes second sound.

Tests verified Landau's theory. When liquid He^{II} passes through a small opening, three microns or less in diameter, atoms of the normal fluid are left behind. Since the superfluid atoms passing through the orifice do not take any thermal energy with them, the temperature on one side of the opening is considerably reduced.

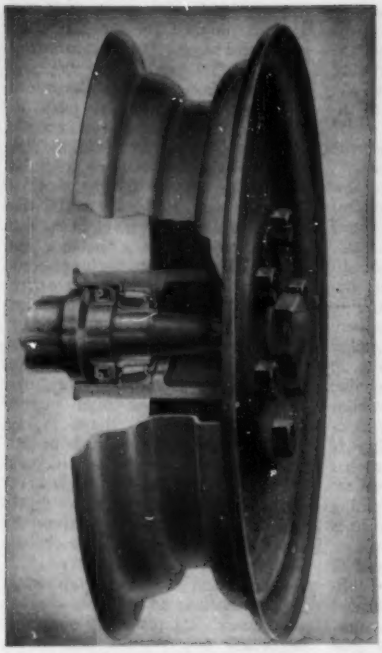


Fig. 1—Spring-loaded leather seal used to protect the bearing of a semi-pneumatic industrial wheel. This type still is one of the most popular seals.

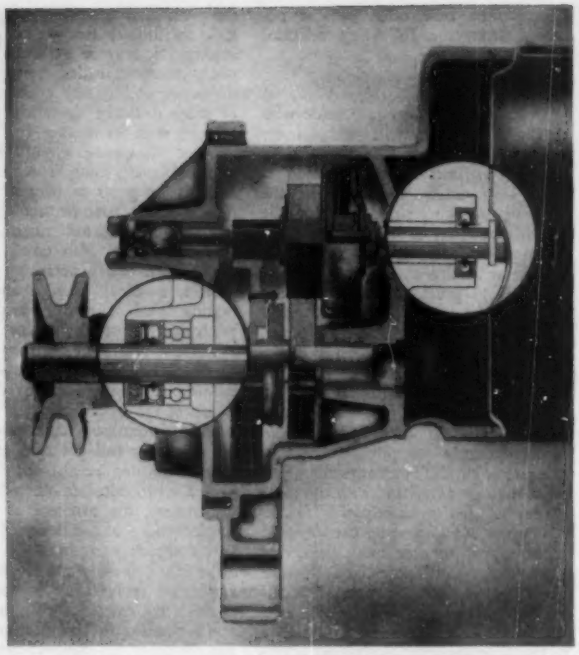


Fig. 2—Gear motor drive having a fluid seal with an outside protective sealing element (left) to exclude foreign abrasive matter from main sealing area and (right) a specially compounded synthetic rubber seal used at high speeds.

Which Shaft Seal?

Shaft tolerances, shaft finish, shaft hardness, operating speed, and other factors must be weighed. The author tabulates the characteristics of the various types of seals such as springless, spring-loaded, dual, and face to make your choice easier.

R. S. RAINEY
Chief Engineer
The National Motor Bearing Company

THE STANDARD TYPE OF SHAFT OIL SEAL has always been a relatively simple product. Nevertheless, it has many constructional features that can be varied to meet different operating requirements. Its physical dimensions can be regulated to conform with a multitude of conditions as also can its sealing qualities. Its materials can be selected to seal against almost any industrial fluid, while the hardness of the compound or other factors can be regulated to meet any set of conditions to obtain adequate seal life, regardless of the operating conditions. Flexibility in these respects has been increased by new synthetic materials and leather processes. The study of such factors as spring tension, shape of the sealing member, amount of shaft interference, combinations of different materials in multiple, the relationships between speed, temperature and pressure in combination with other variables also have helped to bring the shaft seal to its present state of efficiency and adaptability.

THE SPRING-LOADED LEATHER SEAL, Type (*A*) Table I, still represents the major proportion of all oil seal manufacturers' output. It is a general purpose type that is selected when the sealing conditions are known to be non-critical, when peripheral speed is not more than 2,000 fpm, and when service temperatures are not above 200 F. It is not as sensitive to shaft finishes as synthetic seals, and works well when bores are rough. It will withstand exposure to considerable amounts of dust and abrasive particles without auxiliary protection. It should not be used where absolute sealing is required,

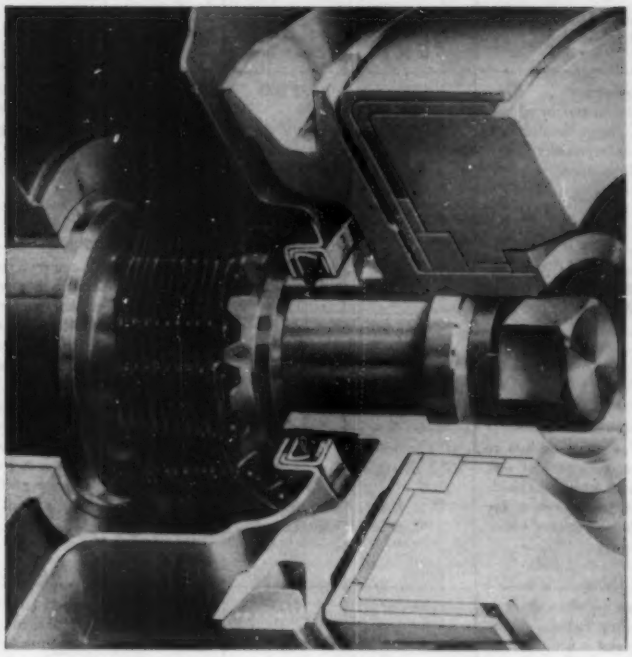


Fig. 3—Typical front bearing seal for an automobile engine application. This is a spring-loaded synthetic seal—a type that is extensively used for general-purpose sealing applications when the equipment operates at moderately high speeds.

as it has some tendency toward slight seepage. It is more effective than types made of synthetic materials when there is little or no lubrication of the bearing—although self-lubricating synthetic types have now been developed that are effective in these starved conditions. It is in use on automobile wheels, both front and rear, where lubricants are not corrosive. It is almost universally recommended for all types of farm equipment and tractors, and for heavy machinery, gear trains, and trucks.

THE SINGLE SPRING-LOADED SYNTHETIC SEAL, Type (*B*) is almost as universal in application as the Type (*A*) seal. It can operate under temperatures up to 300 F at peripheral speeds of up to 4,000 fpm, and with shaft runouts or misalignment as high as 0.030 in. total indicator reading. It is also capable of complete sealing, allowing zero seepage at the lower speeds and temperatures. It can be used on practically all general applications except that it must always have sufficient lubrication, and shaft finish should be better than is necessary with the all-purpose leather type seals. Engines, transmissions, pinions, and other equipment that operate at high speeds represent typical applications.

THE DUAL-TYPE SEAL, Type (*C*) with a single-loaded number and an auxiliary, non-spring loaded member, is used primarily in abrasive atmospheres to exclude small abrasive particles and retain oil or grease. The spring-loaded member may be made of either a synthetic material or leather; the auxiliary member may be made of leather, a synthetic material, felt, or special materials. When the basic member is made of a synthetic rather than leather, the allowable temperature rating and the speed and runout that the seal can withstand are proportionately greater. These seals normally will run at lower speeds and temperatures than their single member counterparts because the auxiliary members retains the heat generated in the assembly. If sufficient lubrication is present, the synthetic and leather types are practically interchangeable up to temperatures of 200 F and speeds of 2,000 fpm. Felt is generally used when the abrasive is light; leather is recommended when the abrasive is mud or heavy dirt; synthetic materials are used under extreme abrasive conditions—mud, dirt, and water—and when the seal is continuously exposed to such conditions as in the application shown in Fig. 4. However, a synthetic auxiliary member is used only when speeds and temperatures are low, because there is generally no way to lubricate the auxiliary.

A COMBINATION SPRING-LOADED SEAL, Type (*H*), with two spring-loaded members opposed, is a type of seal that was designed to separate and retain different fluids in the same application. This type of seal is also specified when it is necessary to retain a lubricant and exclude water. The sealing members may be constructed of leather or a synthetic material, subject to the same conditions as previously described.

THE EXTERNAL EXPANSION SPRING-LOADED SEAL, Type (*C*), was devised because it often is impossible to assemble a seal in a housing and have it operate on a corresponding shaft. Thus, it became necessary to design a seal that could be pressed on the shaft and that would make rubbing contact in the bore. Particularly on wheel or spindle applications does such a design lend itself to easy assembly and disassembly, particularly in the presence of taper-type bearings. Again, rubber is used for the high-temperature and high-speed applications, and leather is used for rougher assembly and lubricant-starved positions. The expanding element may be either an open coiled spring or a piston ring, which is used for slow operating speeds.

THE TANDEM SPRING-LOADED SEAL, Type (*J*), is a type that is not as widely used as the other designs. It is limited in application because the second member usually is starved for lubrication, generally to such an extent that even leather is not always satisfactory. Seals of this type are sometimes

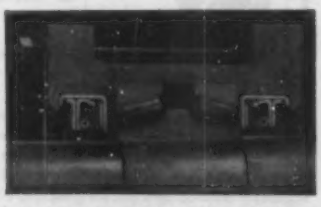
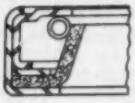
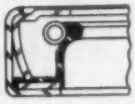
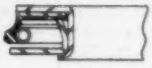
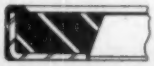


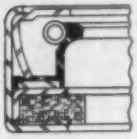
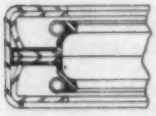
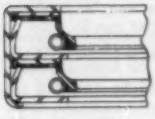
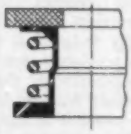
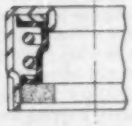
Fig. 4—Dual synthetic spring loaded seal used on disk plow journals to prevent entrance of dirt into and leakage of grease out of the bearing. Such seals are used in dirty atmospheres, but must be operated at slightly lower speeds than single member synthetic seals.

Table I—Common Fluid Seals and Their Applications

Type of Seal	Typical Applications	Operation Limitations		Remarks
		Temp., F	Speed, fpm	
(A) Spring-Loaded Leather Seal 	General purpose uses Automobile wheels, tractor wheels, truck wheels, farm implements. With "B" below, represents 70 percent of all seals produced.	200	2,000	Cannot be used when shaft runout is high, when peripheral speed is over 2,000 fpm, or where temperature is above 200F.
		Sealing Material: Leather		
(B) Spring-Loaded Synthetic Seal 	Engines, transmissions, pinions. In general all applications where the shaft speed is above 2,000 rpm.	300	3,600–4,000	Can be used with temperatures up to 300F, peripheral speeds up to 4,000 fpm, or with shaft runouts as high as 0.030in. Must be used with well finished shafts and should never be used where lubrication is absent or scanty.
		Sealing Material: Synthetic		
(C) External Expansion Spring-Loaded Seal 	For press fit on shaft or hub to effect sealing at periphery of seal. Used particularly on wheel spindle applications on front wheels of any vehicle. Lends itself to easy assembly and disassembly.	300 F synthetic 200 F in leather	3,600–4,000	The external type of seal is useful when the seal rotates rather than the shaft because the centrifugal force in the spring tends to make a tighter seal.
		Sealing Material: Leather or Synthetic		
(D) Springless Leather Seal	General purpose use when space or price is a limiting factor. Also, where a simple seal is necessary, as to retain grease at low speeds. Also often used as a dust seal on auto and truck axles.	180–200	1,000	One of the most simple and inexpensive seals and quite effective against heavy lubricants when speed and temperature are low. Also, is an effective dust and dirt seal.
		Sealing Material: Leather		
(E) Springless Steel Supported Synthetic Seal	Used where space and price are limiting factors but will withstand higher speeds and temperatures than the springless leather seal (D) above. Is beginning to replace spring loaded synthetic seals on simple, low speed applications, as inner automobile axle seals, low speed gear boxes, and farm equipment.	250–300	3,000–3,600	An effective seal which has the advantage of being able to withstand more pressure than above types. Often used with 15 to 25 psi pressure but should not be used where there is excessive runout or whip.
		Sealing Material Synthetic		
(F) Springless Synthetic High-Pressure Seal 	Primarily pressure type seals used in pumps, also used on extremely small shafts where the relation of ID to OD does not allow space for relief as in (E) above.	Variable, usually not over 180	Variable, usually a max. of 800–1,000	An economical type seal often operated at 70-100 psi or higher if speed and temperature are held to a minimum.
		Sealing Material: Synthetic		

recommended for operation under extremely abrasive conditions; in such cases, the sealing members are both pointed away from the grease and are regularly flushed by a grease gun. Double spring-loaded seals still are applied when service speeds and temperatures are high, abrasives are heavy, and a flexible spring-loaded member must be used instead of an inert non-spring loaded auxiliary; but later designs, such as Type (*G*), with a synthetic auxiliary, are rapidly replacing this type of seal.

THE SPRINGLESS LEATHER SEAL, Type (*D*), might properly be described as the simplest oil seal possible. Primarily it is a leather disk that is extensively used whenever space or price is a limiting factor. It must be used, however, only at low speeds and temperatures. It is never considered a complete seal because oil seeps through it to some extent. It is not effective against lubricants of light viscosity. Its principal use is as a heavy grease seal and, more important, as a dust seal. When intended as a dust seal, felt is sometimes used instead of leather, especially if speeds are high. It has been applied on some auto and truck axles, particularly on the front wheels,

Type of Seal	Typical Applications	Operation Limitations		Remarks
		Temp., F	Speed, fpm	
(G) Dual Type Spring-Loaded Seal 	In dust ladened atmospheres or where other abrasive particles must be sealed from the oil. Outer axle seals, front end of engines, unprotected pinions and transmissions.	200	2,000	These are dual type seals. Temperatures and speeds should not be too high because the auxiliary tends to add heat to the operation.
		Sealing Material: Synthetic with auxiliary of leather, felt, or any other required material		
(H) Combination Spring-Loaded Seal 	For separation and retention of two fluids, such as, gear boxes and chains of gears where two types of lubricants are used. Also for gear boxes or other drives operating in water with one member holding oil and the other water	180–200	1,800–2,000	Opposed seals of this type, regardless of what material is used, must be lubricated in some manner from both sides.
		Sealing Material: Leather or Synthetic		
(J) Tandem Spring-Loaded Seal 	For heavy duty applications, or under a head of oil. Or on extreme abrasive conditions where the second member helps to keep abrasives from the main member. Used sometimes on track roller applications, disc plows, etc.	180–200	1,000	Seal is limited as is type (H) above by lack of lubrication on the secondary member. Whenever it is used both members must be lubricated.
		Sealing Material: Leather or Synthetic		
(K) Boot-type Face Seal 	When frictional losses must be lower than with types (A) to (J). Used in water pumps and other types of pumps where friction must be an absolute minimum.	300	4,000–5,000 and up	Has long service life but is more expensive both to manufacture and to arrange in a unit. Special designs can be made for temperatures up to 600 F.
		Sealing Material: Synthetic		
(L) Case-type Face Seal 	When frictional losses must be lower than is gotten with other types. Used in similar positions as (K) above but the seal is entirely unitary and must be pressed into position.	300 Also special materials up to 400	4,000–5,000 and up	The same as (K) above.
		Sealing Material: Synthetic		

on electric motors, and even on simple mechanisms as an all-purpose seal.

THE SPRINGLESS, STEEL-SUPPORTED, SYNTHETIC SEAL was one of the first types of synthetic seals. The inherent resiliency of the rubber in this seal has a somewhat similar action to a spring. It does not withstand shaft eccentricities above approximately 0.010 in. total indicator reading, but if operating conditions are good, complete closure can be made on shafts operating at speeds up to 3,600 fpm and at temperatures as high as 300 F. Generally, it is operated under less exacting conditions to prolong its life. It has the added advantage of being able to withstand pressures on the order of 15 to 25 psi, whereas the normal spring, single-loaded synthetic seal, such as Type (*B*) can only withstand pressures of 5 to 10 pounds per square inch.

THE SPRINGLESS, SYNTHETIC HIGH PRESSURE SEAL, Type (*F*), is a variation of Type (*E*) that is utilized when the ratio between the ID and the OD is too small to allow relief at the lip. It also is capable of withstanding pressures as high as 70 to 100 psi and higher if shaft speed and operating

temperatures are low. Such seals must be used with discretion, however, as the inherently large shaft pressures will burn out the seal if service temperatures or operating speeds are excessive. They are also incapable of taking up any degree of runout or eccentricity. They have been found useful as wipers on reciprocating shafts such as for hydraulic cylinders and pistons.

THE BOOT-TYPE FACE SEAL, Type (*K*), has many specific uses, although the use of face seals versus the standardized shaft seal is still a matter of considerable controversy. Often a face seal is used when a properly designed shaft seal would be as fully effective. Face seals generally are much more expensive to manufacture and to arrange in a unit than are shaft-type seals. When properly designed, however, face seals have the lowest frictional loss of any type; they generate less heat and are capable of taking up more end-play and misalignment. Also, in certain applications they will more effectively retain lubricant and protect the bearing. If not operated under extreme conditions, they have long life.

Face seals are recommended for all types of pumps, particularly automotive water pumps. They also are recommended for precision equipment operating at extreme speeds where low frictional characteristics are a necessary requirement. Many such types of seals are operating at rubbing speeds as high as 5,000 to 6,000 fpm, and it is possible to manufacture them of materials capable of operating in ambient temperature of 600 F. They can also be designed of such material that any type of industrial fluid, including acids, may be used. Type (*K*), shown in the accompanying chart, is for applications involving low speed and relatively clean operating conditions, and where mating parts are such that a drive through the sealing face is not necessary. It is one of the simplest and cheapest forms of face seals but is still relatively expensive.

Graphite sealing faces are used extensively for face seals, especially for sealing against oil, steam, and water in such products as pumps, washing machines, and steam turbines. Other materials, including unpregnated fabrics, are also applied to such seals in many instances.

THE CASE-TYPE FACE SEAL, Type (*L*), is another variation of the face seal that is often used when the seal must be pressed on a housing. It is capable of operating under higher speeds and wider speed variations than Type (*K*), but it is somewhat more expensive to manufacture.

Whenever a face-seal is used, the finishes and tolerances on all the mating surfaces must be considerably more accurate than for a shaft-type seal. Thus, the designer should first consider shaft-type seals before proceeding to the expensive requirements of a face-seal design.

Conditions Affecting Operation

There is much more to successful seal application, however, than mere selection of the seal. The condition of the shaft, of the assembly, and of mating seal surfaces must all be held within specified limits. The major factors affecting seal life and performance are as follows: shaft tolerance and finish; shaft hardness; operating pressure; shaft speed and operating temperature; and eccentricity, whip and runout.

SHAFT TOLERANCE AND FINISH. For fluid sealing applications, a shaft tolerance of ±0.001 in. is recommended, although the average oil seal is effective if the differential is as great as ±0.005 in. However, shaft condition is probably more important than shaft tolerance. The shaft must be round and free of nicks or machining marks that would permit oil to seep under the seal. It should be designed so that there are no keyways, sharp corners, or machined ridges that cut the seal during assembly.

In general, the smoother the finish the longer the life of the seal. Experience has proved, however, that a shaft finish of 15 to 25 mu in. rms is a practical compromise. Such a finish generally can be obtained by standard production methods without prohibitive increases in cost. Either leather or synthetic seals can operate satisfactorily on shafts of this finish; for example, some seals have been operated on test for more than 12,000 hr. at peripheral speeds of 3,600 fpm on shafts of such finish. With speeds of 2,000 to 2,500 fpm, life is measured in years.

In many applications it is necessary to use shafts having a roughness as high as 50 to 65 mu in. rms. If the speed is not too great, the performance, particularly of leather seals, is satisfactory. Tests have been conducted on shafts with finishes up to 150 mu in. rms, but if the speed is in the neighborhood of 3,600 to 4,000 fpm, life may be as short as a few months.

SHAFT HARDNESS. If the shaft is properly finished, shaft hardness is largely dictated by the extent to which abrasive materials are turned into the sealing area. When abrasive conditions are severe, the seal area and bearing area should be flame or case-hardened, at least locally; automotive crank-shaft ends and the drive mechanisms of heavy earth-moving, agricultural or construction equipment are examples of equipment on which this is done. If, however, shaft speeds are relatively low and there are no unusual abrasive conditions, the seals will operate on shafts of cold rolled steel.

HOUSING BORE AND TOLERANCE. The recommended tolerance on housing bores is 0.001 in. In practice, the bore usually is specified with some nominal dimension and the seal is made slightly larger so that it can be pressed in position, the increase usually being from 0.004 to 0.005 in. for shafts of medium sizes. These bores are usually turned, and the finish is in the neighborhood of 40 to 60 mu in. rms. However, it may be difficult or impractical from a cost standpoint to maintain a finish even this fine, and if so, seals with a rubber covering are recommended. They can be used on bores as rough as 100 mu in. rms or greater without sealing compounds.

When designing the housing, sufficient chamfer should be specified on the bore. Without this chamfer, there is danger of scoring or cocking the seal during assembly so that its performance is impaired.

OPERATING PRESSURE. Neither the spring-loaded or springless type of shaft seal was originally designed as a pressure device, but as previously mentioned, recent developments in the field of synthetic materials, have made possible its use under pressure as high as 200 to 300 psi. However, if pressures of even 5 to 15 psi are exerted on a spring-loaded flexible type seal, the operating speed must be below 1,000 fpm and temperatures must not be above 140 to 175 F. There must be no excessive runout or whip and the shaft finish must be 25 mu in. rms. If the pressure is 50 to 100 psi the sealing lip must be thickened, a spring becomes unnecessary, speeds must be lower, and shaft finish should range from 10 to 15 mu in. rms maximum.

Referring to the accompanying chart, the universal type of oil seal, either (*A*) or (*B*) is capable of withstanding pressures of only 5 to 10 psi. Type (*E*), a springless synthetic seal, is capable of 15 to 25 psi. Type (*F*) was designed for operating pressures of 70 to 100 psi, and has been used at pressures of 600 psi under extremely favorable operating conditions but such applications are unusual.

SHAFT SPEED AND OPERATING TEMPERATURE. Probably the most important subject to investigate when selecting a seal is the peripheral or rubbing speed at the sealing surface of the seal. On this, primarily, depends the basic design or type of seal to be used. Leather sealing members have been continuously improved until they are now recommended for peripheral speeds of more than 2,000 fpm; synthetic seal can be operated at peripheral speeds up to 3,600 and even up to 4,000 fpm. Since temperature is generally a function of the peripheral speed, the best types of leather are recommended for temperatures only up to 200 to 225 F, while modern synthetic sealing compounds are capable of 300 to 325 F. Care should be taken that the ambient temperature plus that developed by the rubbing contact of the sealing member does not exceed these limits.

Tests show that a synthetic seal has only one-third to one-half the friction of a leather seal when operating under the same conditions. Both speed and temperature are factors that shorten the life of any seal. Thus, where either is excessive the other should be adjusted. For instance, where a seal is required to operate at 3,000 fpm, or more, ambient temperature should not exceed 200 F, runout or eccentricity should not be more than 0.010 in. total indicator reading, and shaft roughness should not exceed 20 mu in. rms.

Eccentricity, Whip and Runout

Shaft eccentricity, misalignment, momentary whip and end play are conditions that are present in varying degrees wherever shafts turn. These conditions create basic sealing problems; but a proper oil seal can, and does, protect the bearing. When these conditions are severe, specially designed seals are necessary. Exhaustive tests have shown that properly designed synthetic rubber seals, with correct spring tensioning, will operate successfully with shaft eccentricity as high as 0.030 in. total indicator reading at 4,000 rpm. In such cases, it is important that flexibility of the sealing member be balanced exactly with the proper spring tensioning. Again, as with other unusual conditions, excessive eccentricity shortens seal life and should be avoided, but if necessary, other factors such as speed, or shaft finish, can be adjusted to compensate for it.

Actual misalignment of mating parts has a slightly different effect on seals than eccentricity of the shaft itself. Good sealing has been achieved when misalignments were as high as 0.035 in., but to get such satisfying results, surrounding conditions must be the best possible and the seal must be of a special design.

The momentary whip or misalignment that occurs in flexible cranks or drive shafts requires a slightly different flange design. Flexibility and hardness of the sealing member must be so adjusted that the sealing member does not leave the shaft during the whip action. Otherwise, pumping or spurt leakage will occur at intervals.

Excessive end play in a shaft requires a different approach. The flexible design useful for high speeds and temperatures and extreme eccentricity may buckle and misplace itself in relation to the shaft during excessive end movement. A compromise is required to retain the flexibility that is necessary if perfect sealing is to be accomplished, and still obtain a seal that will withstand the endwise movements. Excessive amounts of any of these shaft movements will shorten the life of the oil seal and should be compensated for by other factors. The designer should try to keep eccentricity not over 0.005 in. indicator, misalignment not more than 0.005 to 0.010 in., and shaft end-play not more than 1/32 in. Shaft whip can often be minimized by increasing the size of the shaft or by increasing the number of bearings.

Designing with Dollars Subject of June Issue

THE JUNE 1949 ISSUE OF PRODUCT ENGINEERING contained over 200 case example studies showing methods designers were using to lower the cost of their products through redesign. The subject of cost was important then. It is even more important today. As a result, next month's issue of Product Engineering will again carry data on this subject in a special "Designing with Dollars" section. But instead of case examples, this time the editors have dug deep for basic data on how to design a low cost, high quality product. Besides fundamental articles on methods of organizing a cost analysis group in the engineering department, how to figure the direct and intangible cost of a product, and others, will be 50 pages of "Dollar Saving Tipsheets."

These tipsheets will be divided into groups to facilitate rapid reference. One group will consist of fundamental data for the selection of mechanical transmissions elements. Another with fastenings, mounting and mechanical parts. Still another will cover types of production processes, such as die casting, sand casting, screw machine production, cold heading, and brazing. Nor will materials, hydraulics and pneumatic components, or electrical components be forgotten.

Under mechanical transmissions will be included tipsheets on gears, speed reducers, chain drives, V-belt drives, clutches, couplings, brakes, sleeve bearings, and anti-friction bearings. Besides the previously mentioned subjects, under types of construction will be check lists and tips on impact extrusions, spun parts, stampings, forgings, tubing, cold roll formed sections, powdered metal parts and others. The section on materials will contain tipsheets on the selection of plastics, of finishes, and of ferrous and non-ferrous metals. The electrical section will contain tipsheets on "Ways to Reduce Your Wiring Cost," "Factors that Add to the Cost of Electrical Motors", and others.

It is obvious that such data is very difficult to get and being so the entire issue will be one that engineers will want to keep on the bookshelf for a long time to come. The special issue last year, "Designing for Lower Cost", showed what was being accomplished in terms of redesign by concerns all over the country. This issue, June 1950, tells *how* to go about that redesign.

All told, there will be 64 pages of cost reduction data that will help you to approach the problem of cost analyses for your product in a practical way.

The concerns who have contributed to this issue would make a "Who's Who" of American industry. The editors firmly believe that both the subject and the material make this an issue that no reader can afford to miss.

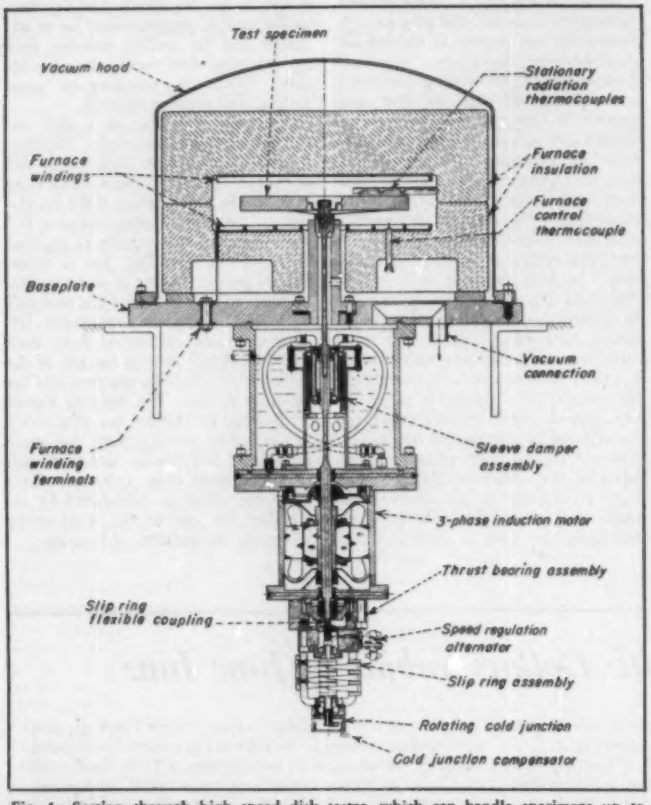


Fig. 1—Section through high speed disk tester, which can handle specimens up to 14 in. diameter and 2.0 in. thick. The specimen can be rotated at speeds up to 35,000 rpm, and held at temperatures up to 1,500 F. Larger specimens can be tested with only slight modification of the equipment, and specimen temperature can be maintained uniform or varied in radial gradients up to about 100 F per inch.

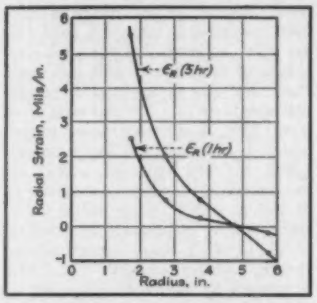


Fig. 2—Radial strain at 1.0 hr and 5.0 hr on a special high temperature alloy when run at 20,000 rpm and 1,200 F.

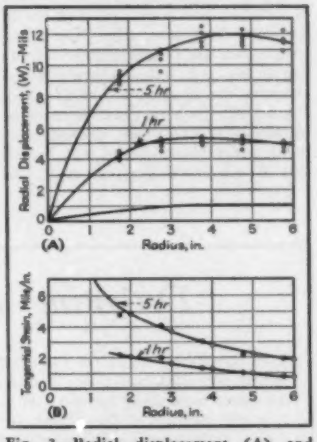


Fig. 3—Radial displacement (A) and tangential strain (B) for the same specimen used to obtain the data for Fig. 2. Open points on (A) are calculated tangential strains, others measured.

High Temperature Testing Machine

From "A High-Speed, High-Temperature Precision Testing Machine for Gas Turbine Disk Research" by A. C. Hagg, B. Cametti, and G. O. Sankey, Westinghouse Research Laboratories. Presented at the Annual Meeting of the Society of Experimental Stress Analysis, December, 1949.

A PRECISION TESTING machine has been designed to carry out a part of a research project to determine the strength of gas-turbine disks. Experimental studies with this equipment are conducted in parallel with theoretical studies and have as their objective the development and evaluation of disk design calculation methods.

The machine can handle disk specimens up to 14 in. dia. and 2 in. thick, and larger specimens can be handled with only minor modifications. The specimen is mounted with the axis vertical on a flexible shaft; the driving motor is of the induction type and covers a speed range up to 35,000 rpm. The furnace is designed for a specimen temperature up to 1500 F. The specimen temperature may be uniform or arranged for radial gradients up to about 100 F per inch.

Primary design emphasis was placed on means for accurate measurement and control of specimen speed and temperature, and on the determination of plastic and creep strains. Average speed error for a run is less than 0.01 percent; the maximum instantaneous error is about 0.5 percent. Specimen temperature is continuously measured and recorded using specially developed thermocouple circuits and slip-ring

coupling; temperature errors are less than 10 F by test calibrations. Plastic and creep strains are measured over the disk surfaces in radial and tangential directions utilizing punch marked spacings. The average error in strain measurement is 5 percent.

General Description of Machine

A cross-sectional view of the disk testing machine is shown in Fig. 1. The disk specimen is mounted by a screwed fastening to the top of a vertical flexible shaft. The drive is a plain bearing 3-phase induction motor with a variable frequency power supply. A damping element located between the disk and the motor is attached to the flexible shaft through plain bearings and is effective in controlling vibration amplitude at the critical speeds and in overcoming energy sources that might otherwise lead to self-excited oscillations of the system. The thrust of the rotating system is taken by a Kingsbury-type bearing at the underside of the motor. All bearings are lubricated with light spindle oil at 30 psi pressure.

The furnace encloses the disk specimen; for uniform temperature runs, a two-section grid type resistance winding of Nichrome strap is located one section below and one section above the disk with the grid pattern at right angles to each other. By test, with thermocouples located at inner, outer and intermediate radii, this heater gives uniformity of specimen temperature to within 5 F. A radial temperature gradient in the test disk is obtained by a circumferential grid-type resistance winding radiating heat to the outside thickness area, and by conduction to and radiation from the disk faces to adjacent cooled surfaces. The thermal insulation sections are cast to size using high temperature insulating cement. The metal enclosure is made in thin section ($\frac{1}{8}$ in.) so that in event of failure the disk fragments will pierce the section with a minimum of scuffing on fracture surfaces.

Removal of the metal furnace enclosure and the top insulating section is a minor operation thus making installation, removal, or inspection of the disk specimen quite convenient.

Rotating thermocouple circuits are used for measurement of specimen temperature. The slip-ring coupling for these circuits is attached to the lower end of the motor shaft. A detailed description of this rotating thermocouple circuit is included in the original paper, as well as a description of specimen preparation and test procedures and of the equipment and techniques for the measurement and/or control of temperature, speed, and strain.

The time required to carry out a test exclusive of the actual running time is approximately 150 man hours; this corresponds to two men working a two week period. During a test run present practice is to have an operator in attendance, although the operator is for the most part free to carry out other parts of the testing sequence such as strain measurements on previous or succeeding test disks.

To illustrate the type of information obtained in the tests, the data of Figs. 2 and 3 are presented. In Fig. 2 radial strains are shown for a 1 hour and a 5 hour run on a special high temperature alloy at 1,200 F and 20,000 rpm. Fig. 3(A) shows radial displacement and Fig. 3(B) are calculated tangential strains from the radial displacement curve and the solid points plotted on the same figure are the measured tangential strains.

Results from the equipment have been consistently good.

Selenium and Copper Oxide Rectifiers

Foreign abstract from "The Characteristics and Applications of Metal Rectifiers", P. A. Goodyer, The Transactions of the S. A. Institute of Electrical Engineers, Johannesburg, South Africa, July 1949.

IMPORTANT DEVELOPMENTS in physical and electrical research, coupled with improvemets in manufacturing technique have, during the recent war, considerably improved the characteristics and greatly extended the field of application of metal rectifiers.

Of the many types of "dry plate" or "barrier layer" rectifiers developed, the copper oxide and selenium types are by far the most well-known, mainly by reason of the fact that they have proved by far the most successful. The paper is confined mainly to a brief consideration of the characteristics and a more detailed treatment of the applications of the modern selenium-compound rectifier, which has superseded its copper oxide equivalent for industrial and power applications.

It is emphasized, however, that the copper oxide rectifier is not by any means obsolete, in that it possesses characteristics which cause it to be selected for use in certain circuits in preference to the selenium type.

Following now is a comparison between the characteristics of the selenium and copper oxide types.

MAXIMUM OPERATING TEMPERATURE. The reverse resistance of the copper oxide rectifier decreases appreciably at temperatures above 55 C with a consequent rapid increase in the reverse and total losses. In addition, creep in the copper oxide rectifier usually results in an increase of reverse current with time. For these reasons the copper oxide element should not be operated at a temperature higher than 55C. The selenium rectifier may be run at temperatures up to 75 C.

The efficiency of the latest selenium-compound rectifiers exceeds 90 percent. This compares with the figure of about 80 percent obtainable with copper oxide elements.

REVERSE VOLTAGE PER ELEMENT. The selenium element and particularly the "double-voltage" type recently developed may be operated at a considerably higher reverse voltage. Except in the case of low-voltage applications, the assembled rectifier unit contains only from one-half to a quarter of the number of series elements used in the copper oxide type for the same output.

BULK, WEIGHT AND COST. The three factors already referred to combine to bring about a considerable reduction in the bulk and weight of the selenium rectifier as compared with a copper oxide unit designed to give the same output. The reasons are summarized below:

(a) The increase from 55 C to 75 C in the permissible operating temperature gives an increased temperature gradient between the rectifier and the surrounding air and permits a substantial reduction in the area of the cooling fins or heat-dissipating surface.

(b) In view of the increased efficiency of the selenium rectifier, the total power loss to be dissipated is greatly reduced. This further reduces the radiating surface necessary.

(c) Due to the higher operating voltage per element the number of rectifier elements employed may be reduced substantially.

The reduction in bulk and weight is accompanied by a reduction in manufacturing cost.

STABILITY. The rapid increase in reverse current at elevated temperatures and the existence of the positive creep phenomenon in the copper oxide rec-

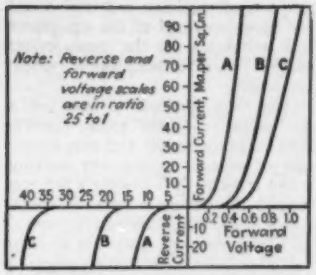


Fig. 1—Typical characteristic curves for metal rectifier. Curves A, B and C are for copper oxide, selenium and double-voltage selenium, respectively.

tifier combine to make it unstable if the temperature is high or the loading excessive, when its losses and temperature rise may increase rapidly and indefinitely. No such instability exists in the case of the selenium rectifier.

AGING. In the case of the copper oxide rectifier the forward resistance may be substantially increased by aging, particularly if the operating temperature is high.

The magnitude of the increase in forward resistance is smaller in the selenium rectifier.

SUITABILITY FOR OIL-IMMERSION. The selenium rectifier is particularly suited for oil-immersion. This is an important advantage, since industrial rectifiers of the air-cooled type, in spite of improvements in protective coatings, cannot be expected to withstand extremely humid conditions or exposure to corrosive atmosphere for long periods.

SELF-CAPACITANCE. A copper oxide rectifier unit, designed to operate at a given voltage, has a lower self-capacitance than the equivalent selenium unit. This has the effect of decreasing the reverse leakage at relatively high frequencies.

SHAPE OF CHARACTERISTIC. The "bottom bend" of the forward characteristic occurs at roughly 0.25 volt for copper oxide and 0.5 volt for selenium at 20 C. The copper oxide characteristic is therefore linear down to a lower voltage and this fact, together with its lower self-capacitance, gives it a substantial advantage over the selenium type for instrument rectification and for certain high-frequency applications.

REVERSE VOLTAGE PEAKS. Whereas the maximum rated reverse voltage applied to a copper oxide rectifier may be increased under conditions of intermittent application to about twice the normal value, that applied to the selenium rectifier should not be exceeded, even momentarily.

It is clear from this summary that while the last three factors explain the reason for retention of the copper oxide rectifier in instrument and communication circuits, the first seven are overwhelmingly in favor of the selenium-compound type for power applications. One field where dry rectifiers are extensively used is the motor control field.

Rototrol Regulators on Machine Tools

From "The Application of the Rototrol Rotating Regulator to Machine Tools" by M. H. Fisher, Westinghouse Electric Corporation, presented at the AIEE Fall General Meeting, Cincinnati, 1949.

IN THE ORIGINAL FORM, this paper included a discussion of the requirements of adjustable speed drives for machine tools, and gave detailed data on Rototrol circuits and characteristics. The Rototrol is a special d-c generator having

(1) Extra long poles to accommodate more than the usual amount of copper

(2) The poles and frame comprising the stationary magnetic path annealed to reduce the residual magnetism effects.

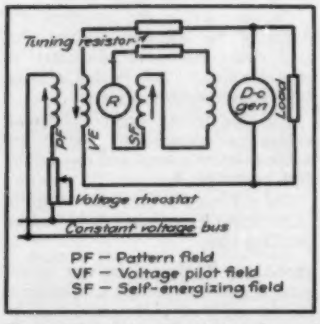
(3) The armature usually constructed of paper and steel laminations arranged alternately to make the armature ½ paper and ½ steel. This forces the armature to saturate before the stationary structure and reduces th. hysteresis effects.

In a standard series generator, the self-exciting winding is connected in series with the load and both the load and the series winding comprise a shunt circuit across the armature. The series field current is then directly proportional to the armature voltage in the same manner as obtained for a self-excited shunt wound machine. The Rototrol usually makes use of this series self-energized circuit, Fig. 1.

The functions of the three Rototrol fields shown in this illustration are as follows:

FIELD SF. The self-energizing field. This field, connected in the armature circuit supplies the ampere-turns necessary to produce the voltage output of the Rototrol.

FIELD PF. The pattern field. This field is energized from a constant-voltage



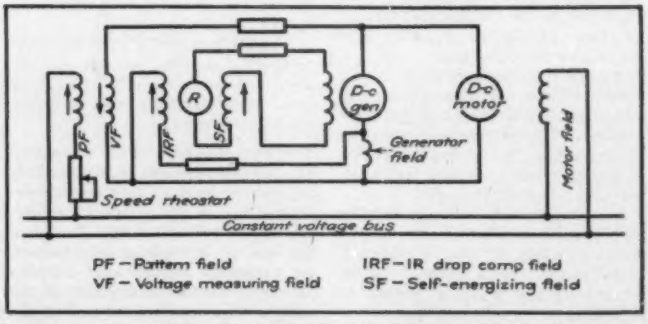


Fig. 1—Circuit for the simplest form of Rototrol rotating regulator. Fig. 2—Circuit of simple counter EMF speed regulator.

source and serves to set the pattern for the regulated quantity. The value of the quantity, in this case the generator voltage, can be adjusted by means of a rheostat in the field circuit.

FIELD VF. The pilot field. This provides the means for measuring the regulated quantity and comparing it with the pattern.

Fig. 2 shows the voltage regulator as shown in Fig. 1 modified to be a counter EMF speed regulator. A current measuring field (IRF) is added to the circuit. The strength of this field is adjusted to compensate approximately for the IR drop lost in the generator and motor armature.

Although Fig. 3(A) bears little resemblance to the previous relatively simple circuit diagram of Fig. 2, if the components of this diagram be closely examined, the same basic circuits will be apparent. It shows the bridge with the Rototrol connected into the circuit. The pattern fields are now self-energizing fields.

Although the Rototrol has been applied to machine tools most actively as a speed regulator, a special current limit type has been applied to dynetric balance machines. In these balancing machines, the current limit regulator effectively limits the accelerating and decelerating torque transmitted through a delicate coupling located between the motor and the mass to be balanced to the maximum safe value which can be transmitted through the coupling without damage.

The circuit used for the dynetric balancing machine is shown in Fig. 4. In operation the field rheostat on the motor and generator are usually preset for a motor speed depending on the object to be balanced. The switch is then operated to start the motor. In the first instant after closing the switch, the pattern field PF is excited cumulatively. Next the current field *CF* becomes excited cumulatively due to current starting to build up in the generator-motor armature loop. In the meantime, the current in the slower generator field is increasing but due to the output of the current limit regulator opposing the separate excitation of the generator fields, the generator voltage is limited to a value determined by the pattern field, current field, and the differential voltage field of the regulator. As the drive motor accelerates, the ampere-turn value of the differential voltage field gradually increases until it exactly cancels the pattern field ampere-turns.

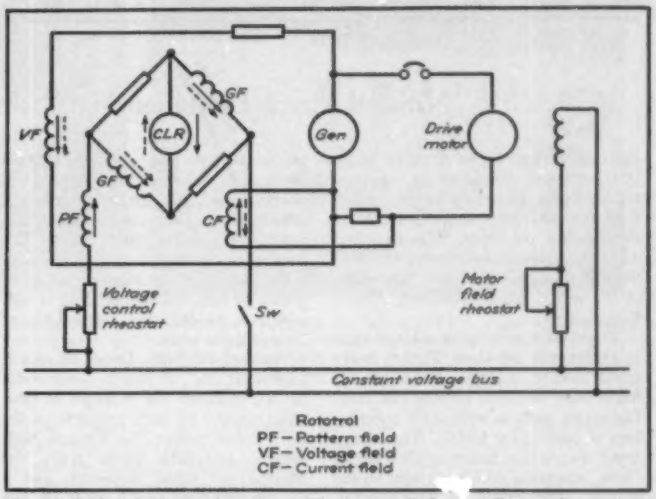


Fig. 3—Bridge circuit speed regulator. The pattern fields are self-regulating.

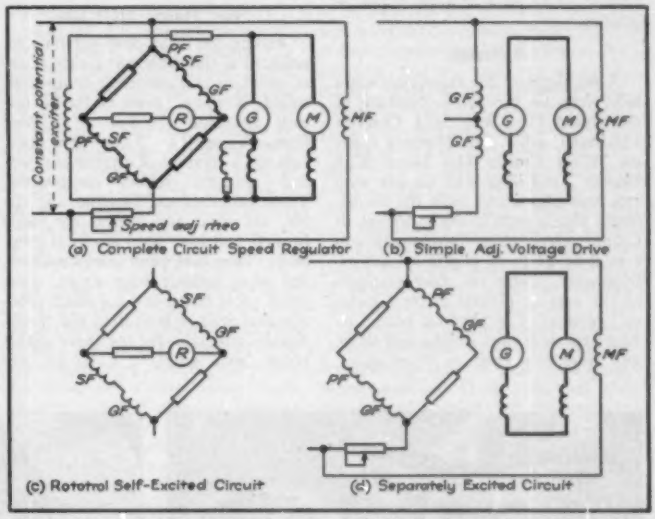


Fig. 4—Curren. limiting, acceleration control circuit for dynetric balancing machine.

On deceleration the switch is opened, the current in the generator-motor loop reverses, reversing the current field. The differential voltage field remains in the same direction. The combination of current field and voltage field causes the regulator to sustain the field on the generator to regeneratively brake the load to a stop with a definite current limit.

Although the Rototrol can be used for the regulation of voltage, current, speed, torque, tension and numerous other quantities which can be measured electrically, the applications discussed in this article represent only two of these many functions.

Additional circuits were included in the full paper presented by the author, and detailed descriptions of the circuits, plus some of their advantages and applications as well as some of their limitations were included. The reader also is referred to previously published data that appeared in PRODUCT ENGINEERING.

TECHNICAL NEWS

National Plastic Exposition Has Redesign Theme

FEATURING THE MOST RECENT PRODUCTS, technical developments, and applications in the ever-growing plastics field, the exhibits of more than 120 of the leading producers, manufacturers and users of plastics occupied over 96,000 sq ft of Chicago's Navy Pier at the recent fourth National Plastics Exposition.

There were three outstanding trends in evidence at the show. First, a heavy trend toward redesign. Redesigns for lower costs included revisions of existing plastic parts as well as the substitution of plastics for metals. The second trend was in the heavy application of "new" materials which are now on the market after extensive development. The third main trend was toward secondary or by-product applications of plastics.

Redesign

A highlight of the exposition was a talk given by Mr. O. E. Norberg of the Crosley Div., Avco Mfg. Corp. of Cincinnati, Ohio. Mr. Norberg spoke on "What Crosley Has Done With Plastics", and illustrated his talk with case examples drawn from the 68 different plastic parts in the 1950 line of Crosley refrigerators. Crosley now uses a total of 24 lb of plastic in each refrigerator. These are some examples of the uses of plastics in the Crosley refrigerator: The phenolic plastic refrigerator door liner weighs only six lb, and saves two extra cu ft of space; plastic shelves and injection molded shelf rails enhance the product appearance and have the same structural advantages as the riveted aluminum previously used; a nylon roller is incorporated in the door latch; and a baffle assembly, previously made of plastic by compression molding is now injection molded at a cost saving of 75 cents per piece.

Another exhibitor, Durez Plastics & Chemicals, Inc., of North Tonawanda, N. Y., featured the redesign to phenolic plastics of such products as the Cory coffee brewer, the Burgess paint sprayer, industrial rayon gears, the Morton salt tablet dispenser, and a one hp reversing switch made by The Furnas Electric Co. of Batavia, Ill.

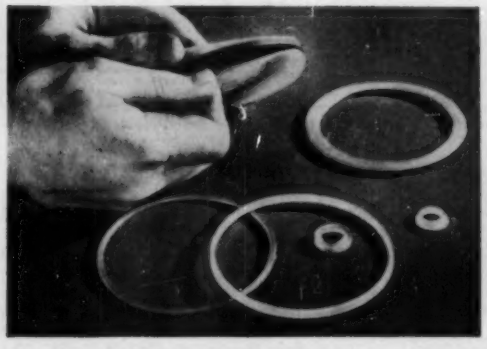
New Plastic Materials

Among the many new materials announced at the show was a new group of molding and extrusion compounds called "Kralastic" made by the Naugatuck Chemical Division of United States Rubber Co. These new materials are a mixture of styrene and several synthetic rubber components. These materials are dimensionally stable, are rigid and tough, are easily formed, and have good electrical properties. They have been used for chemical pipe, cathode edge strips, cams, gears, cable floats, and for other products that must be both hard and tough. Tensile strengths for the three grades range from 4,300 to 5,100 psi and hardnesses range from 87 to 103, Rockwell. The same compound produced in sheet form is called "Royalite" by another division of the U. S. Rubber Co.

Durez introduced a new phenolic resin compound, Durez 9841, and a new mineral-filled phenolic molding compound, Durez 14893. The first formulation is made specifically for use as an insulation coating for electrical parts. The latter, Durez 14893, is especially good for molding around insets. It features excellent heat resistance, good finish, extremely fast cure, and a low specific gravity.

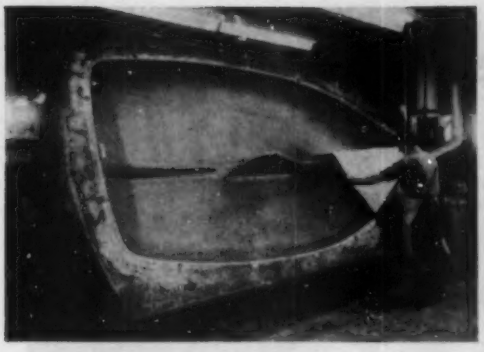
The Bakelite Div. of Union Carbide and Carbon Corp. announced "Bakelite C-22", a new class of fast curing general-purpose phenolics that are suitable for compression and plunger molding in positive or semi-positive molds. The big factor here is the speed of cure, which is from 15 to 45 percent faster than the curing rates of standard "fast curing" phenolics.

A silicone-glass molding compound displayed by the General Electric Company's Chemical Department created a great deal of interest. Outstanding heat resistance is the principal feature of this new material. It withstands continuous operation at 392 F, G-E says. G-E 12810 also has high impact resistance and excellent arc resistance, as well as good flow in the mold. It will not support combustion and tests show it has no toxicity when burned. This

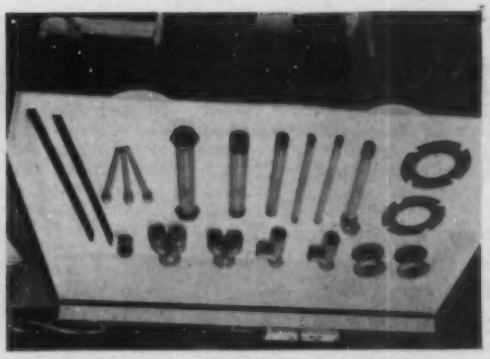


THESE GASKETS AND "O" RINGS, made by the U. S. Gasket Co., are fabricated from "Kel-F", a fluorocarbon-type thermoplastic that combines the resiliency of rubber with resistance to attack from almost any known type of corrosive.

ELECTRIC SANDER, displayed at the Exposition by the Celanese Corp. of America, features a "Lamarith XF" handle, which has high heat and flame resistance and the high finish and toughness needed for this particular application.



ONE STEP in the manufacture of seamless, one-piece boats made by the Beetle Boat Co., New Bedford, Mass. Boats were on display at the American Cyanamid booth. They are from "Laminac" Resin-Fiberglas.



TYPICAL PRODUCTS OF "KRALASTIC", a new molding and extrusion compound made by the Naugatuck Chemical Div. of U. S. Rubber Co. Parts include wire spools, cams, pipe fittings, textile bobbins and cathode strips.

new compound is ideally suited for circuit breakers, switchgear and other parts where resistance to extreme heat and impact is necessary.

Three new synthetic rubber-phenolic molding compounds recently developed by the Chemical Department of the General Electric Co. were also displayed. The new compounds consist of an asbestos-filled, a cotton flock-filled, and a fabric-filled compound. Each of these compounds has unusual shock, vibration, and fatigue resistance, plus the characteristics of the filler material. The internal resiliency of these new compounds is derived from their synthetic rubber component (Hycar), a product of B. F. Goodrich Chemical Company.

The Celanese Corp. of America displayed their main cellulosics in the form of toys, household appliances, and decorative items. They also featured an insulation material made of multiple laminations of cellulose acetate foil. Called Isoflex, the material is new to the U. S.—it has been used before in Europe. The Isoflex Corp. of San Francisco, Calif., will manufacture the material. A new plastic laminated tubing, in which glass cloth, mat, or tape is molded together with polyester resins, was the outstanding feature of the U. S. Plywood Corp. display. The new piping has high corrosion, chemical, and heat resistance.

Many of the industrial applications of "Kel-F", a fluorocarbon-type thermoplastic, were displayed by the M. W. Kellogg Co., Jersey City, N. J. The material's principal use is for hose sealing rings, and pump packing. Rohm & Haas exhibited several new products made of modified styrene. Products low pressure molded from "Laminac", a thermosetting polyester resin, and glass fibers, were given considerable space in the American Cyanamid Company's exhibit.

A new thermoplastic structural material, polystyrene latex loaded glass mat, was featured in the Monsanto booth. The material is a combination of chopped strand glass mat, (which is a product of the Owens-Corning Fiberglas Corp.), and "Lustrex", a polystyrene latex. The material should be molded in a compression machine on a short press-time cycle. A new vinyl product, "Marvinol VR-20", attracted a great deal of interest. It is produced by the Naugatuck Chemical Div. of the U. S. Rubber Co., and is especially useful for covering electrical wire and cable.

Secondary Applications

The exhibit of the Plaskon Div., Libby-Owens-Ford Glass Co., gave a good example of a new material that influenced redesign of auxiliary production equipment. Plaskon had previously developed a fast curing alkyd resin with excellent electrical applications—however, existing equipment was not set up to handle this new material. This year, the Plaskon booth had three different presses, made by three different companies, to handle the new material. The companies were: Elmes Engineering Div. of American Steel Foundries; The Denison Engineering Co., and Baker Bros., Inc.

A good example of the secondary or by-product application of plastics was introduced at the Bakelite exhibit. A new foundry process, known as the Croning process, employs a resin-binder developed by the Bakelite Div., Union Carbide and Carbon Corp., for producing cores and molds from sand. Although resins have been used for many years in sand core bonding, the new method is a radical departure in that it does not require long baking and curing and uses relatively small volumes of sand. The process, controlled by Crown Casting Associated, of Boston, Mass., produces castings that come out of the mold with clean sharp edges, true dimensions and unchilled surfaces that require little or no finishing such as sand blasting or wheel-abrading. It is said that the quality and precision of the castings produced by the Croning process are increased to the point where tolerances from 0.002 to 0.003 in. per in. can be made standard foundry practice.

Manufacturers Adopt Simplified Convector Standards

MORE THAN 300 MANUFACTURERS AND DISTRIBUTORS have now accepted the Bureau of Standards-sponsored simplified practical recommendations for heating convectors, the government agency reported last month.

Designated as Simplified Practice Recommendation R238-50, the voluntary agreements went into effect January 1 of this year.

The Recommendation establishes a simplified list of four types of convectors in a number of sizes in each of two categories. The Bureau of Standards reports that the list represents a substantial reduction in the number of combinations manufactured. Adherence to this simplified list should enable producers, distributors and users to enjoy the same bene-

fits which other industries have experienced from the application of simplified practice to their products. Formerly, one manufacturer could possibly make over a million combinations of convector styles.

Now They've Done It—Jet Propelled Top Sergeants

CALLED THE "TOP SERGEANT", a new pulsejet helicopter is now undergoing tests at Manhattan Beach, California. The new ship, which was designed and built by the American Helicopter Company under an Air Force development contract, uses small jet engines on the tips of its rotor blades.

After surveying the results of a year's preliminary development work A-H Co.'s president, Corwin D. Denney, announced that the payload of a pulsejet helicopter should be double that of a piston-engined helicopter of the same gross weight. Lower cost features and structural simplicity are further advantages. The company estimates production costs of about one-fourth that of the lowest-priced commercial helicopter. Maintenance and overhaul costs should also be much lower than usual. The use of low grades of kerosene or jet fuel by the pulsejet should lower fire risks and operating costs materially.

The two jet engines situated on the rotor tips weigh less than 50 lbs, or less than 25 lbs per engine. They replace conventional reciprocating engines weighing 300 lbs. The only engine system accessories are an electrically driven fuel pump, throttle, master shutoff valves, fuel flow gage, and a rotary fuel line transfer seal. Two rotor mounting bearings are the only highly loaded moving parts in the helicopter's structure.

The company does not plan to increase the size or thrust of their basic pulsejet engine. When heavier ships are built several standard jet engines can be added to each rotor to build up the required thrust. Early engine designs which failed under whirl loads of up to 200-G have been corrected and now show no structural weakness. Pulsejet engine valve blocks, the only moving engine component, which once had a relatively short life expectancy now are performing for hours and improved designs now under test should have a life of 30 hours or more. Replacement of a worn valve block can be done in the field in 5 minutes and is the only major overhaul required for a pulsejet. A new engine configuration just recently evolved should substantially reduce the drag of pulsejets mounted at rotor tips.

ALAN THOMPSON, production superintendent of American Helicopter Co. holds the entire power plant of the "Top Sergeant" in his hands. The conventional helicopter engine in the foreground weighs 300 lbs. The two jet engines that furnish the full power for the new ship weigh less than 25 lbs apiece.

SMALL JET ENGINES on the tips of the rotor blades drive the new "Top Sergeant" helicopter on its test flight at Manhattan Beach, California. Tests indicate that the experimental aircraft will lift a greater payload than conventional 'Copters.

University of Illinois Dedicates New ME Building

THE DEPARTMENT OF MECHANICAL ENGINEERING of the University of Illinois announces the dedication of a new Mechanical Engineering building on May 12 and 13 at Urbana, Ill. The dedication will be held concurrently with the Mid-Western Conference on Fluid Dynamics, and the meeting of the fluid dynamics Div. of the American Physical Society.

The program will include addresses under the following subject headings: Aerodynamics—External Flow; Mechanical Engineering—Internal Flow; Hypersonic and Low-Density Flow Techniques; Turbulence and Aero-Physics; Astro-Physics, Computing Machines, and Meteorology; and Hydraulics and Continuation of External and Internal Flow. The program will conclude with a discussion of future programs.

Washington Notes

Wanted: A Cheap Death Ray

The National Inventors Council in Washington has put out a call for a death ray, new communication inventions, new dry and wet cell batteries and 27 other badly needed inventions. The Council warns that a good death ray shouldn't use much power, and must be effective at 500 yards. The death ray is the only futuristic item in the list. Other items wanted are more commonplace, although at first glance they present problems that seem insolvable.

The NIC was originally created in August 1940 by the Secretary of Commerce with the concurrence of the President. During the war years the Council screened over 200,000 inventions for the armed forces. Many of them played an important part in the war—the magnetic mine detector, for example. Since then the Council has continued to function in the Department of Commerce with an OK from the Defense Department.

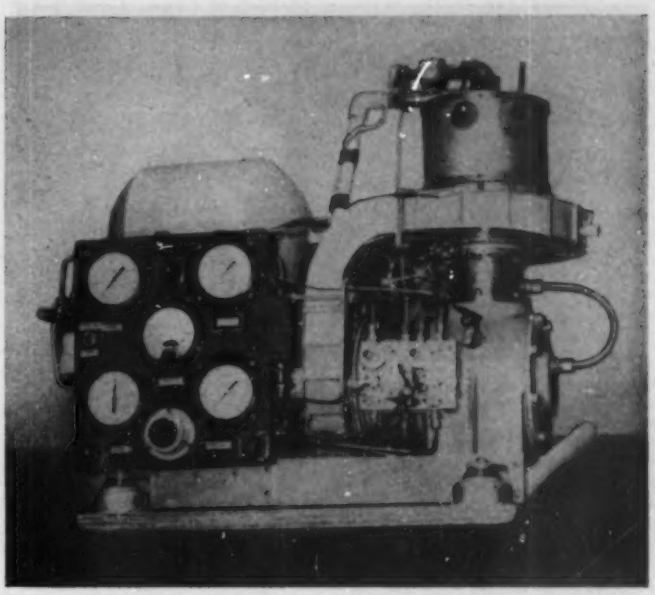
A list of needed inventions has been issued annually since the war. In the latest edition nine of 27 problems listed have a bearing on construction in the Arctic zone and operations of equipment in cold weather. Here are a few of the inventions needed: The military services want a "revolutionary new method of transmitting intelligence." Present systems in general depend on electrical impulses, electromagnetic waves, sound waves, etc. A system utilizing completely new concepts is desired, says the NIC. It would be used to replace or augment present systems. Also wanted is equipment capable of translating ordinary speech into the written word. The aim is to speed up communication. The equipment wanted must be of size suitable for general use.

The list includes one "atomic war" item. The Army wants a "convenient pocket size radiation indicating and measuring instrument." This should be of such size and cost that every soldier potentially subject to radiation exposure could be equipped with one.

The Army also wants someone to develop a portable steam generator with adequate nozzles for both jetting and thawing under Arctic conditions. These nozzles must be capable of jetting holes for anchors, deadmen, piles, foundations and artillery emplacements. Nozzles are required for the large-scale thawing of ground so that bulldozers, graders, or shovels can be used in building airfields.

The services also want to get small lightweight equipment suitable for heating dry batteries so that full output can be obtained in regions where temperature drops to —65 F. Investigations and experiments have been conducted using heat tablets, Sterno-type heaters, oxidation of thermophoric materials, activated charcoal blocks, and chemical heaters. None of these, to date, has resulted in a practical battery heating device suitable for use in Arctic regions.

The ordinary wet battery is also giving trouble. The Army wants to find a way of converting automotive-type (lead-acid) storage batteries for use at temperatures in the —65 to



The Hot Air Engine—An Old Idea Pays Off

AN "EXTERNAL" COMBUSTION ENGINE is now performing a life test at the U. S. Naval Engineering Experiment Station at Annapolis, Md. It differs from the usual engine in that all combustion takes place outside of the cylinder.

The main advantage of the "hot air" engine is in its extreme quietness. Another advantage is the ability to burn coal, wood, or any other available fuel, and to start and run under extremely cold conditions. To offset these advantages is a high weight to power ratio and the fact that it takes several minutes after lighting the fire before starting the engine.

The Stirling, or "hot air" cycle was first developed about 1816 by a Scottish clergyman and engines employing this cycle were widely used during the 19th century. When more efficient cycles were developed at the end of the 19th century interest in the Stirling cycle waned and the hot air engine was almost forgotten. Then, in 1937 the Philips Company of Eindhoven, Holland became interested and began to apply modern design knowledge and materials. Although they still don't have all the problems licked, especially the weight vs power ratio, the company has built workable engines in sizes up to 50 hp.

In 1946 work was started in the United States under a Navy contract. The engine in the illustration is the result of this development. It will not only permit further study of the Stirling cycle, but also has possible use as a portable generator set for wartime front line radio work.

New Transmission Line Rivals Coaxial Cable

THE "G-STRING" TRANSMISSION LINE, a simple wire with special insulation and funnel-shaped terminals, may replace the coaxial cable for many applications. Dr. George Goubau, of the Signal Corps Engineering Laboratories, Fort Monmouth, N. J. invented the new transmission device. Here he is shown at one end of his experimental line in the Signal Corp Engineering Laboratory.

The line, which is simple, highly efficient, and costs little to manufacture, promises to open up wholly new possibilities in microwaves and home television. The Signal Corps, which calls the device a "G-string" after the inventor's initials, expects it to bring important improvements to radar operation. It also may replace coaxial cable, which is both intricate and expensive for many applications.

The G-string also may make practical the development of a videophone, by which a telephone subscriber could go to his local exchange, pick up an instrument, and talk to a friend across the continent—and both parties see each other. The new Signal Corps line could carry a hundred such videophone conversations simultaneously on a single wire, compared with the ability of today's single coaxial cable to carry only one.

—170 F region. The method must be simple and foolproof, and capable of being accomplished by comparatively unskilled personnel. Either a new type of electrolyte or an additive to present electrolyte is wanted. The additive would have to have low viscosity at extreme low temperatures.

Interested persons can get a full list of wanted inventions from the council. Department of Commerce technicians state that no special forms are required for submitting proposals to the National Inventors Council. Address the council at the Department of Commerce, 14th St. between Constitution Ave. and E St., Washington 25, D. C. Each proposal should be submitted as a separate document, preferably typewritten. It should contain complete information on the principles underlying the operation of the apparatus or invention together with a discussion of any tests which have been conducted. The particular points of novelty or superiority of the apparatus as compared with existing devices or practices should be stressed.

Fire Retardant Paints To be Tested

The National Bureau of Standards is planning a project to develop a comprehensive battery of tests to establish the limits of effectiveness of paints advertised or commonly accepted as "fire retardant."

Nolan D. Mitchel of the Bureau of Standards recently said that although some tests of retardant paints have been made for a few Federal agencies, no comprehensive test has been established. He suggested reducing the coated combustible to a "slow-burning" category. Because people want a paint that will not burn, they extend the meaning of the term "fire-resistant" to mean "fire-proof."

Unfortunately, there is no fireproof paint. Under sustained, severe fire exposure there are no impregnation treatments or paint coatings that will give complete protection. But, a fire-retardant paint will control the spread of fire. The paints are not permanent, but will last for several years.

Fire-retardant chemicals mixed with ordinary paint for outside use haven't proved practical as yet. Neither oil- or water-base paints mixed with protective chemicals have the durability to withstand the elements for any length of time. Mr. Mitchel said that the Bureau of Standards is particularly desirous of setting up a testing project.

The object would be to develop a thorough test for all surface finishes to enable classifying these materials in accordance with fire resistance, flame spread and combustibility. Protection afforded the backing material, amount and quality of smoke, and the toxicity of gases generated, would also be part of the resulting classification.

One-Armed Robots Are to be Used in Radioactive Areas

A one-armed robot on wheels, capable of closing doors, turning valves, taking apart and reassembling complex machinery, in fact performing almost every task the human hand can perform has been developed for use in radioactive areas. Known as a "tool dolly", the device was designed by General Electric engineers for use on projects which the company is conducting for the Atomic Energy Commission. It is rolled into radioactive areas where men cannot go and operated by remote control from a shielded adjacent room. It moves under its own power along narrow gauge railroad tracks. Both power and control are supplied through 6 cables which lead to the power source, General Electric engineers explained.

Weighing approximately 5 tons, the dolly resembles a railroad hand car with a small calibre deck gun mounted on it which is a telescoping arm with double clamps similar to artificial

hands used by amputees. The arm can be extended or shortened, raised or lowered, by remote control. The hand is capable of wrist bending motion, rotating and gripping. Six small electric motors are in the arm and hand and 24 in the entire unit.

The dolly is also equipped with a hydraulically-driven ram, electrically controlled, capable of delivering a 4-ton push; rotating devices for opening and closing valves and taking apart or reassembling specific types of machinery.

General Electric engineers say that a man can be trained to operate the dolly in a week. The controls are mounted in two boxes about the size of small suitcases. There are 23 switches, nine for controlling the hand and arm. Six cables to connect the controls to the dolly.

Second Product Design Seminar Planned for June

THE SUCCESS OF THE FIRST PRODUCT DESIGN SEMINAR, held at Lehigh University last summer, has led to the planning of a second seminar which will run from June 26 to July 21 of this year. Just as last year, the meeting will be sponsored by Lehigh University and the Society of Industrial Designers.

The 1950 session will follow the same basic pattern of the first seminar, but will run for six weeks rather than four. Under this lengthened schedule companies will be better able to send key personnel as delegates.

The idea for such a seminar started several years ago when Mr. Einar M. Ramberg of the Department of Industrial Engineering at Lehigh realized the need for better understanding between the product design engineer and the industrial designer. After interesting the authorities at Lehigh University in this idea, Ramberg approached the Society of Industrial Designers. The Society accepted the invitation to work out plans for the proposed seminar and appointed Raymond Spilman, New York industrial designer and member of the Society's Committee on Education, to work with Mr. Ramberg on the development of a program for the first seminar.

Acting as co-directors, Ramberg and Spilman drew up the following statement of objectives:

1. To analyze the economic, competitive, and social status of industrial design in American industry.

2. To demonstrate through actual examples the procedure followed in successful design projects, and the form of organization required.

3. To analyze the factors which must be considered in the solution of design problems — consumer research, esthetics, production techniques, and availability of materials.

Although the profession of industrial design was thus a key concept in the plan of the Seminar, it was treated, quite properly, as an orienting factor in the analysis of production problems, rather than as the subject for study itself. The purpose of the Seminar was not to train industrial designers, or even to offer a refresher course. The program was geared to the needs of engineers and others who deal with industrial designers, and who need in their daily work to understand the profession and the kinds of service it renders. To develop this understanding the schedule included talks by many of the best-known designers, in which each explained the solution to problems with which he had been identified. Besides the lectures and talks by industrial designers, representatives of industrial firms gave talks on various problems likely to arise in mass production industries. Each of the fundamental manufacturing materials was discussed.

Applications are now being accepted for attendance at the second annual seminar. Companies wishing to send delegates are urged to contact Mr. E. M. Ramberg at Lehigh University at once. Delegates will be limited in numbers. Application blanks are now available.

Watch the June Issue

READERS remembering the special, June 1949 issue on "Designing for Lower Costs," will be anxious to see this year's June issue. Next month's special issue will again carry cost reduction data in a special "Designing With Dollars" section. Instead of case examples, the editors have dug deeply into the basic factors affecting the design of a low cost, quality product. The special section will include fundamental articles in addition to about 50 pages of "Dollar Saving Tipsheets". All told, there will be 64 pages of cost reduction design data to help you design your quality product with the right material, and with the right method. Watch for it—in June 1950 PRODUCT ENGINEERING.

News Briefs

SAN FRANCISCO'S BAY AREA has been picked as the location of the Atomic Energy Commission's newest classified project. The AEC project will cost about $7,000,000 and will involve the construction of a particle accelerator.

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COMBAT AIRCRAFT are expected to remain subsonic for many years, according to Carl C. Sorgen, of the Bureau of Aeronautics, Department of the Navy. Mr. Sorgen, in a speech to the ASME, said the brute force required for propulsion beyond the sonic barrier made aircraft "tremendously expensive."

•

THE NATIONAL SCIENCE FOUNDATION BILL received a set-back when the Senate disagreed with the House version of the bill. The five senators appointed to a conference committee on the bill are known to be against the drastic loyalty provisions of the measure.

•

A NEW FRENCH STEEL FORMING PROCESS soon to be introduced in the U. S. uses a modified form of hydraulic press and permits continuous hot-forming of shapes that cannot be made in rolling mills because of their complex profiles. The process also permits shaping of certain tough alloy steels not previously subject to rolling.

•

THE ATOMIC ENERGY COMMISSION recently has made available to American industry 67 patents acquired by the Commission in its atomic work. These patents, owned by the U. S. government, will be licensed on a non-exclusive, royalty-free basis.

•

REVISION of all the common thermocouple tables is being undertaken by National Bureau of Standards, Washington, D. C., to take into account the recent changes in electrical units and in the international temperature scale.

•

A NEW TITANIUM ALLOY is slated for use in Navy jet engines. Compressor turbine blades, tailpipe shrouds, engine firewalls and the engine itself are spots where the new alloy will replace steel.

•

THE GREATEST CONCENTRATION OF ENERGY ever produced by man against a single particle of matter has been unleashed at Nevis, Irvington-on-Hudson, site of Columbia University's new nuclear physics research center

Dow Corning Silicone News

DOW CORNING CORPORATION, MIDLAND, MICHIGAN • APRIL, 1950

DOW CORNING SILICONE INSULATION SAVES OVER $8,000 A YEAR ON 4 MOTORS

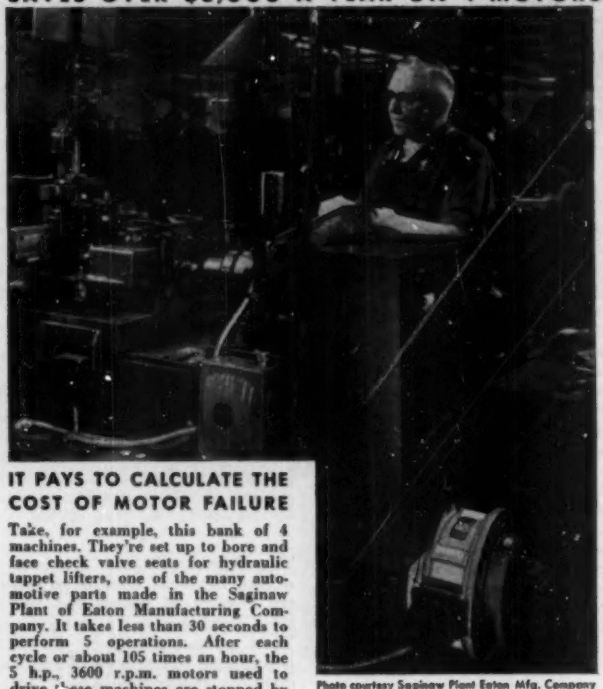


Photo courtesy Saginaw Plant Eaton Mfg. Company

IT PAYS TO CALCULATE THE COST OF MOTOR FAILURE

Take, for example, this bank of 4 machines. They're set up to bore and face check valve seats for hydraulic tappet lifters, one of the many automotive parts made in the Saginaw Plant of Eaton Manufacturing Company. It takes less than 30 seconds to perform 5 operations. After each cycle or about 105 times an hour, the 5 h.p., 3600 r.p.m. motors used to drive these machines are stopped by applying direct current to the windings. That steps up production, but it raises hob with ordinary motors.

In this service, Class A insulated motors lasted from 2 days to 2 weeks or an average of about 8 days. That amounts to something like 32 failures per year per motor. Each failure cost at least 3 hours of down time plus $80.00 for rewinding with Class A materials. At this rate, it would have cost the Saginaw Plant $10,000 a year to keep the four machines operating!

About a year ago, these motors were rewound with Dow Corning Silicone (Class H) Insulation at a cost of about $150.00 each. Minimum life for Class H motors in this service is 6 months. Maintenance costs that would have totalled $10,000 a year have been cut to $1,200. That's a net saving of more than $8,000 plus a good 400 man hours of labor and a bonus of some 40,000 parts that would have been lost because of down time.

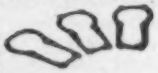
Industry needs the kind of help you can give by using Dow Corning Silicone (Class H) Insulation to cut maintenance costs, to increase productivity or to reduce the size and weight of motors, generators, transformers and solenoids by 50 to 100%. For more information on Silicone Insulation, call our nearest branch office or write for data sheet Q-16.

Courtesy United Air Lines

SILASTIC*

SAVES 93% OF THE FLIGHT DELAYS CAUSED BY PUSH-ROD PACKING LEAKAGE.

Pushrod housing seals fabricated of Silastic by the Arrowhead Rubber Company of Downey, California, remain soft and pliable after 1100 engine hours in contact with hot oil at operating temperatures in the range of 450°F. That kind of performance has almost eliminated flight delays due to pushrod packing leakage. Use of these Silastic seals also cuts maintenance costs and minimizes the hazard of oil leakage.



ARROWHEAD'S new rocker box cover gaskets of Silastic are also gaining general acceptance in the air transport industry. Tests in service indicate that these Silastic gaskets are easier to install and that they have superior resistance to compression, hot oil and high operating temperatures.

That kind of performance is characteristic of the many Silastic seals used in aircraft, automobile and diesel electric engines. New Silastic stocks introduced during the past year have multiplied the usefulness of silicone rubber as an extreme temperature material for gasketing and sealing and for insulating wire, cable and electrical equipment. Notable improvements in physical properties and fabrication technics have greatly increased the usefulness of mechanical goods molded of Silastic. For more information call our nearest branch office or write for data sheet Q-16A.

*T.M. Reg. U.S. Pat. Off.

Dow Corning
FIRST IN SILICONES

Dow Corning Silicones Mean Business!

ATLANTA • CHICAGO • CLEVELAND • DALLAS • LOS ANGELES • NEW YORK

In Canada: Fiberglas Canada, Ltd., Toronto • In Great Britain: Albright and Wilson, Ltd., London

Some Preferred Precision Casting Alloys

Precision Metalsmiths, Inc.

ALLOY STEELS

S.A.E. No.	NOMINAL COMPOSITION										HEAT TREATMENT				PHYSICAL PROPERTIES			MECHANICAL PROPERTIES								
																		ANNEALED				HEAT TREATED (MAX)				As Cast
	C	Mn	Si	P Max	S Max	Cr	Ni	Mo	V Min	Al	Anneal	Normal	Quench	Temper	Thermal Expansion	A_1	A_3	Yield	Ultimate	Elon	BHN	Yield	Ultimate	Elon	BHN	BHN
1010	0.10	0.45		.040	.050						1650F	1625F			7.0 x 10⁻⁶F			35,000	60,000	30	116					120
1016	0.16	0.75		.040	.050						1650	1650	1625F	800-1350F	6.6 x 10⁻⁶F											130
1020	0.20	0.45		.040	.050						1600	1675	1600	300-1400	6.5 x 10⁻⁶F	1300F	1470F	40,000	60,000	35	130	48,000	78,000	12	150	135
1095	0.95	0.40		.040	.050						1500	1525	1600	300-1200	6.2 x 10⁻⁶F		1325	65,000	127,000	5	250				500	260
1314	0.14	1.75	0.25	.040	.040						1675	1650														
3120	0.20	0.70	0.25	0.40	.040	0.65	1.25				1650	1700	1600	300-1200		1290	1470								415	
3140	0.40	0.80	0.25	.040	.040	0.65	1.25				1575	1575	1500	800-1250	6.6 x 10⁻⁶F	1325	1355	64,000	96,000	26	197	230,000	270,000	5	575	205
3312	0.12	0.50	0.25	0.25	0.25	1.60	3.50				1675	1675	1475	300-1200	6.5 x 10⁻⁶F	1250	1340	75,000	90,000	28	185	180,000	220,000	12	375	195
4130	0.30	0.50	0.25	.040	.040	0.95		0.20			1550	1650	1575	800-1200	6.2 x 10⁻⁶F	1340	1445	60,000	89,000	32	190				515	220
4140	0.40	0.85	0.25	.040	.040	0.95		0.20			1525	1650	1550	500-1300		1315	1380	63,000	90,000	19	190	230,000	265,000	8	575	225
4340	0.40	0.70	0.25	.040	.040	0.80	1.85	0.25			1550	1550	1500	400-1200		1035	1320	69,000	100,000	20	200	245,000	290,000	10	600	230
4615	0.15	0.35	0.25	.040	.040		1.85	0.25			1700	1700	1500	100-600		1275	1420	48,000	78,000	33	140	85,000	135,000	23	275	160
4620	0.20	0.55	0.25	.040	.040		1.85	0.25			1700	1700	1500	300-1300		1260	1380	46,000	78,000	25	150	155,000	195,000	16	320	165
52100	1.00	0.35	0.25	.025	.025	1.45					1425		1525	800-1200	7.1 x 10⁻⁶F	1350	1375	81,000	100,000	25	195	227,000	240,000	5	685	210
6150	0.50	0.80	0.25	.040	.040	0.95			0.15		1525	1675	1575	400-1200		1325	1400	58,000	91,000	22	185	270,000	310,000	7	610	200
8620	0.20	0.80	0.25	.040	.040	0.50	0.55	0.20			1700	1700	1500	200-1300		1300	1470	65,000	93,000	25	190	110,000	145,000	16	415	205
Nitralloy 135	0.35	0.55	0.30			1.15		0.20		1.00	1700	1800	1725	1100-1300	6.5 x 10⁻⁶F			85,000	110,000	30	190	155,000	180,000	12	400	200

SPECIAL ALLOYS

NAME	NOMINAL COMPOSITION								PHYSICAL PROPERTIES				MECHANICAL PROPERTIES					GENERAL CHARACTERISTICS	
													ANNEALED				As Cast	Machinability	USES
	C	Mn	Si		Ni		Al	Cu	Sp. Gr.	Thermal Expansion	Magnetic	Modulus of Elasticity	Tensile	Compress	BHN	Izod Impact	BHN		
ALNICO				Fe / Bal	17.0	12.5	10.0	6.0	7.05		Yes							Nil	For Permanent Magnets
DOWMETAL C		0.10 min	0.3 max	Mg / Bal	0.01 max	Zn / 2.4	9.0	0.25 max	1.82	14.5 x 10⁻⁶/F	No				59		60	GOOD	
Ni-RESIST, IA	2.80	1.25	2.25	Cr / 2.25	15.5	Fe / Bal		6.5	7.35	10.66 x 10⁻⁶/F	No	16,300,000	40,000	130,000	145	130	155	GOOD	Wear & Corrosion Resistance

(continued on page 161)

What an Appliance Maker learned from an Automotive Specialist about DIE CASTING...

BUILDING appliances was an old story to a well-known manufacturer but he knew the reputation of the automotive industry for getting quality products at low cost. He figured that any firm with the know-how to serve the car-making industry might be able to show him ways to improve quality and save money doing it. So when a rather unusual die casting and plating requirement came up, he got in touch with the Auto-Lite Die Casting Division. The result was an improved casting and a saving in money, too.

If you have a die casting requirement in which quality or price is a problem, or if you need the help of Auto-Lite's famous design and engineering experts, write to

THE ELECTRIC AUTO-LITE COMPANY
Die Casting Division
Lockland, Ohio

Woodstock, Illinois
600 So. Michigan Ave., Chicago 5, Illinois
723 New Center Bldg., Detroit 2, Michigan

die castings
plastics
wire and cable
industrial
thermometers

Precision Casting Alloys (continued)

Precision Metalsmiths, Inc.

ALUMINUM ALLOYS

INDENTIFICATION	NOMINAL COMPOSITION									PHYSICAL PROPERTIES		HEAT TREATMENT		MECHANICAL PROPERTIES								
														ANNEALED					AGED			
NAME	Cr	Cu	Fe Max	Mg	Mn Max	Ni	Si	Ti Max	Zn	Sp. Gr.	Thermal Expansion	Solution Heat Treat	Age Harden (Max)	Yield	Ultimate	Elong.	BHN	Endurance	Yield	Ultimate	Elong.	BHN	Endurance
142		4.0	1.00	1.50	0.10	2.0	0.80 Max	0.20	0.03 Max	2.73	12.5 x 10⁻⁶/F	970– 6 hr.	650– 2 hr.	18,000	27,000	1.0	70	6,500	34,000	40,000	1.0	105	10,500
220		0.20 Max	0.30	10.0	0.10		0.20 Max		0.10 Max	2.58	13.6 x 10⁻⁶/F			25,000	46,000	14.0	75	7,000					
355		1.00 Max	0.60	0.50	0.10		5.0	0.20	0.10 Max	2.70	12.2 x 10⁻⁶/F	980– 8 hr.	310– 4 hr.	24,000	30,000	2.0	75		27,000	43,000	4.0	90	9,000
356		0.20 Max	0.60	0.30	0.10		7.0	0.20	0.10 Max	2.68	11.9 x 10⁻⁶/F	1000–12 hr.	310– 4 hr.	20,000	25,000	2.0	60	7,500	27,000	40,000	5.0	90	
40E	0.50	0.30 Max	0.30	0.60	0.30			0.20	5.50	2.81	13.7 x 10⁻⁶/F		355–10 hr.	25,000	35,000	5.0	80	9,000					

COBALT ALLOYS

	NOMINAL COMPOSITION								PHYSICAL PROPERTIES		Heat Treatment	MECHANICAL PROPERTIES									
												AS CAST					AGE HARDENED				
NAME	C	Cr	Fe	Mn	Mo	Ni	Ta or Cb	W	Sp. Gr.	Expansion Thermal	Age Hardening	Yield	Ultimate	Elong.	Modulus of Elasticity	BHN	Yield	Ultimate	Elong.	R. A.	Modulus of Elasticity
Stellite No. 21	0.25	27.0	2.0		5.5	2.5			8.30	8.38 x 10⁻⁶/F	1350°F-50 hr.	63,500	101,000	8.2	36,000,000		64,000	124,000	1.7	3.5	29,000,000
Stellite No. 31	0.50	25.0	2.0			10.0		8.0	8.61	8.75 x 10⁻⁶/F	1350°F-50 hr.	51,000	113,000	8.0	36,000,000		68,000	128,300	2.0	2.9	27,000,000
Tantung G	3.00	30.0	4.0	2.0			5.0	16.0		7.5 x 10⁻⁶/F			65,000			654					

NICKEL ALLOYS

NAME	NOMINAL COMPOSITION								PHYSICAL PROPERTIES		ANNEAL Temp.	MECHANICAL PROPERTIES											
												AS CAST				ANNEALED				HEAT TREATED			
		C	Cr	Cu	Fe	Ni	S	Si	Sp. Gr.	Thermal Expansion		Yield	Ultimate	Elong.	BHN	Yield	Ultimate	Elong.	BHN	Yield	Ultimate	Elong.	BHN
Electro-Nickel		Tr		0.02	0.02	99.95	Tr	Tr	8.90	7.4 x 10⁻⁶/F	1100	25,000	55,000	50	125	20,000	60,000	40	100				
Beryllium-Nickel	Be 2.75	0.50 Max	0.75			Bal			8.36	6.4 x 10⁻⁶/F	1925	90,000	120,000	10	225	80,000	110,000	15	200	175,000	230,000		515
Inconel	Mn 0.80	0.20	13.5	0.25	6.0	77.5	0.01 Max	2.00	8.30	7.2 x 10⁻⁶/F	1600	40,000	90,000	20	190	35,000	90,000	45	165	130,000	155,000	5	360
Monel	Al Max 0.50			2.30 Min	3.5 Max	60.0 Min		2.0	8.63	7.3 x 10⁻⁶/F	1700	35,000	80,000	30	150	35,000	75,000	40	125	85,000	105,000	5	240

(continued on page 163)

No matter what structural materials are used, your products or equipment will last no longer than the fasteners that hold them together.

This is why many fabricators and contractors rely on fasteners made of Armco Stainless Steel bars and wire.

Stainless fasteners offer these advantages:

1. Top corrosion resistance for *long trouble-free service life.*
2. Threads of this hard, solid metal stand up under driving and repeated use.
3. Costly repairs encountered when ordinary fasteners fail due to severe rusting or heat oxidation are eliminated with stainless.
4. No discoloration of adjacent materials.
5. In some cases stainless fasteners are competitive in price with fasteners made of plated metals.

THEY FABRICATE READILY

Manufacturers of bolts, nuts, screws, nails, rivets and washers find that Armco Stainless Steel bars and wire are well suited to "upsetting" and machining.

If you want fasteners that *last,* consider stainless steel. No other metal can give you the combination of high corrosion resistance, strength, durability and attractive appearance that stainless steel offers.

Write for more information.

SEE OUR CATALOG IN SWEET'S FILE

ARMCO

ARMCO STEEL CORPORATION

4530 Curtis Street, Middletown, Ohio • Plants and Sales Offices from Coast to Coast • The Armco International Corporation, World-Wide

Precision Casting Alloys (continued)

Precision Metalsmiths, Inc.

COPPER ALLOYS

NAME	NOMINAL COMPOSITION														PHYSICAL PROPERTIES				ANNEAL	MECHANICAL PROPERTIES ANNEALED				
	Al	Be	Bi Max	Cu	Fe	Mn Max	Ni	O Max	P	Pb	S Max	Sb Max	Si	Sn	Zn	Sp. Gr.	Thermal Expansion	Thermal Conductivity	% IACS	Temp F	Yield	Ultimate	Elong.	Shear	BHN
Aluminum-Bronze	10.0			86.9 Min	1.10	1.00									Bal	8.15	9.5 x 10⁻⁶/F	35	14	1625	30,000	70,000	30		130
Beryllium-Copper		2.75		Bal	0.12		1.10									8.23	17.2 x 10⁻⁶/F	49	15	1425	25,000	70,000	50		135
Die-Cast Brass	0.15			60.0	0.75 Max		0.50 Max		0.05 Max	1.25				0.75	Bal	8.40	12.0 x 10⁻⁶/F		25						140
Electrolyte Copper			.001	99.9 Min				0.04			.003					8.91	9.6 x 10⁻⁶/F	225	101	950	10,000	32,000	50	22,000	
Manganese-Bronze	1.00			57.5	1.00	1.50	0.50 Max			0.30 Max				1.00 Max	Bal	8.20	12.0 x 10⁻⁶/F	61	18		25,000	70,000	30		140
Naval Brass				60.5	0.10 Max					0.20 Max				0.75	Bal	8.41	11.8 x 10⁻⁶/F	67	25	950	25,000	57,000	50	40,000	120
Nickel Silver				65.0	1.00 Max		20.5			4.0	0.05	0.25	0.05 Max	4.0	Bal	8.85	9.0 x 10⁻⁶/F	14	6		25,000	40,000	15		105
Phosphor-Bronze				Bal	0.10 Max				0.15	0.05 Max				8.0	0.20 Max	8.80	10.1 x 10⁻⁶/F	36	13	1075	16,000	35,000			65
Silicon Bronze				94.8 Min	1.50 Max	1.50	0.50 Max			0.05 Max			3.20	0.75 Max	1.00	8.53	10.0 x 10⁻⁶/F	21	7	1100	22,000	55,000	50		75

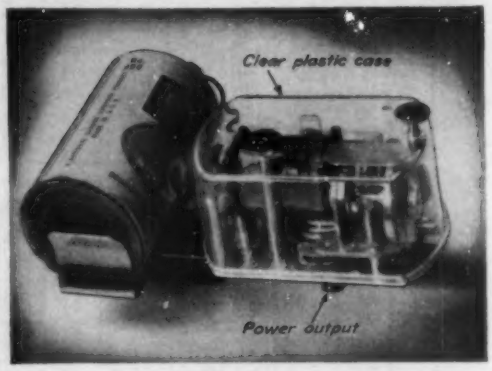
STAINLESS STEELS

IDENTIFICATION		NOMINAL COMPOSITION								PHYSICAL PROPERTIES				MECHANICAL PROPERTIES							HEAT TREATMENT		
AISI TYPE	S.A.E. No.	C	Mn Max	Si Max	P Max	S Max	CR	Ni	Others	Magnetic	Sp. Gr.	Thermal Expansion	Modulus of Elasticity	As Cast Rockwell Hardness	ANNEALED Yield	Ultimate	Elon	R.A.	Izod Impact	Rockwell Hardness	MAX Rockwell Hardness	Anneal	Quench	Temper
302	30302F	0.15 Max	2.00	1.00			18.0	9.0	P, Se, S Min 0.07 Zr, Mo Max 0.60	No	8.01	9.6 x 10⁻⁶/F	28.0 x 10⁶	B-85	35,000	90,000	50	55	80	B-84		1925F		
304	30304	0.08 Max	2.00	1.00	0.04	0.03	19.0	9.5		No	8.01	9.6 x 10⁻⁶/F	28.0 x 10⁶	B-85	35,000	85,000	60	70	110	B-81		2000		
310	30310	0.25 Max	2.00	1.50	0.04	0.03	25.0	20.5		No	8.01	8.0 x 10⁻⁶/F	28.0 x 10⁶	B-85	40,000	85,000	35	60	100	B-81		2025		
316	30316	0.10 Max	2.00	1.00	0.04	0.03	17.0	12.0		No	7.98	8.9 x 10⁻⁶/F	28.0 x 10⁶	B-85	35,000	85,000	60	70	110	B-81		2000		
410	51410	0.15 Max	1.00	1.00	0.04	0.03	12.5			Yes	7.86	5.5 x 10⁻⁶/F	29.0 x 10⁶	B-85	40,000	75,000	35	70	90	B-82	C-41	1575	1725F	300-1200F
416	51416	0.15 Max	1.25	1.00			13.0		P, Se, S Min 0.07 Zr, Mo Max 0.60	Yes	7.86	5.5 x 10⁻⁶/F	29.0 x 10⁶	B-90	40,000	75,000	30	60	70	B-82	C-41	1575	1775	300-1200
420	51420	0.15 Min	1.00	1.00	0.04	0.03	13.0			Yes	7.86	5.7 x 10⁻⁶/F	29.0 x 10⁶	B-98	50,000	90,000	28	59		B-93	C-53	1600	1850	300-800
440C	51440C	1.00	1.00	1.00	0.04	0.03	17.0			Yes	7.86	5.6 x 10⁻⁶/F	29.0 x 10⁶	B-95	65,000	110,000	15	30		B-97	C-59	1575	1800	300-800
17-4-PH ARMCO		0.05 Max					16.5		Cu-4.00	Yes				C-40	160,000	135,000	10	50	35	C-30	C-45	1850	1850	600-1200

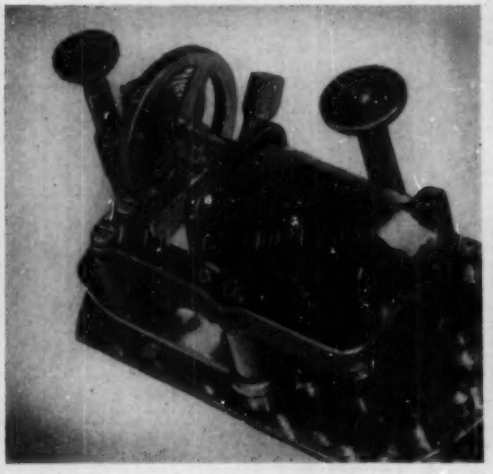
Electric Timing Device Has Accuracy of Watch, Runs on Flashlight Battery

Developed originally as a clock movement, this timing device also has a definite usage as a precision timer in the industrial field. It is small, accurate, and completely self contained. All power is drawn from a single, flashlight type, dry cell battery. This battery will last a full year under continuous use. Accuracy of timing does not depend on the age or amount of charge of the battery. The battery supplies an infinitesimal current intermittently, the hairspring and escapement provide the accurate timing. The balance has four ruby jewels and a rust-proof hair spring. The timer can be regulated from outside the case by a fine micro-metric hair spring adjustment.

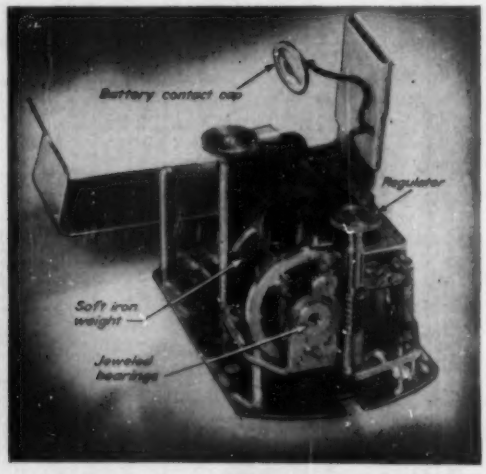
El Products Corp., 501 Madison Ave., New York 22, N. Y.



THE ELIX-365 TIMING DEVICE has the sensitivity and accuracy of a watch or fine clock, yet runs for entire year on one flashlight battery and withstands the rough treatment inherent in industrial applications. The unit measures 2¾ by 1¾ by 1¼ in., and normally comes with a clear plastic cover. Power output is in two speeds, like the hands of a clock.



WHEN CONTACT SPRING MAKES CONTACT the coil is energized and attracts the soft iron counterweight. This magnetic attraction lasts for only a fractional part of the swing, most of the motion being due to the inertia of balance wheel and iron mass. The hairspring is compressed during the balance swing and causes a return swing. On the return swing, the contact spring slides over the contact shoe, and there is no electrical contact to energize the coil and retard the return swing.



A SINGLE DRY CELL BATTERY fits into the clip with the contact post of the battery covered by the contact cap of the timing assembly. The soft iron weight is magnetically attracted when the coil is intermittently energized by a leaf-type contact spring. The balance assembly makes a complete outward and return swing every ½ sec., with the spring making a contact during only 1/13 of that time. The movement can be grounded out for momentary stops, on special applications.

Small Variable Delivery Hydraulic Pump Has Pulsation-Free Delivery at High Pressure

20 hp pump delivers up to 6 gpm at 5,000 psi under constant-duty, manual control conditions.

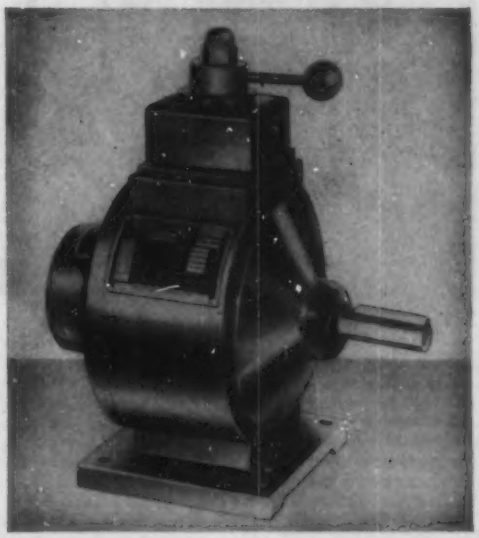
Made for convenient control of machine operation without variation in the motor speed, this unit is a smaller model of an already existing line. The new pump is called the "Superdraulic Junior", and is a variable delivery model. A similar model, with constant delivery, is also available.

This variable delivery model comes in two types. Type CAA is flange mounted, and model CBA is base mounted. Both types require an input of 14 hp at 1,200 rpm to delivery 4 gpm, and an input of 20 hp at 1,800 rpm to deliver 6 gpm. These figures are for operation at 5,000 psi, under manual control.

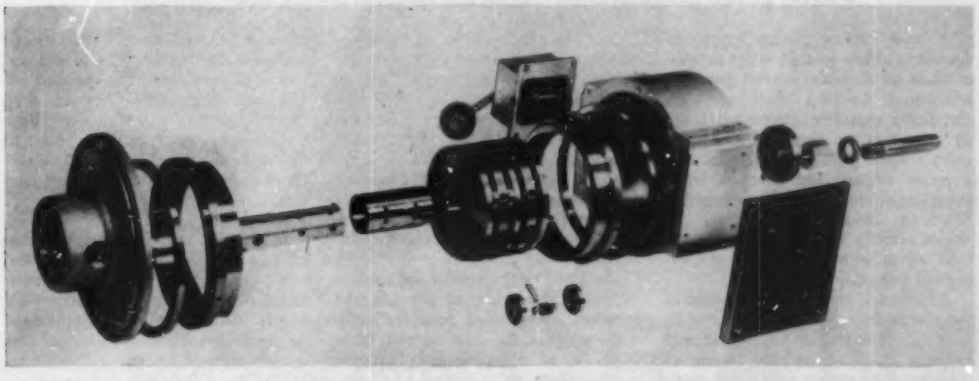
The "Junior" is a radial type plunger pump arranged so that centrifugal force maintains the plunger rollers in contact with an elliptical reaction ring. The plungers are fitted to cylinders in a rotor having two banks of eleven plungers each. The rotor rotates on a fixed pintle which has ducts and ports for directing the oil inlet into those cylinders passing through two opposite quadrants, and also for directing the oil delivery out of those cylinders passing through the other two opposite quadrants.

The plunger rollers of each bank roll against a separate elliptical reaction ring. These reaction rings are geared together and can be rotated in the pump housing by the volume control gear.

Superdraulic Corp., 14256 Wyoming Ave., Detroit 4, Mich.



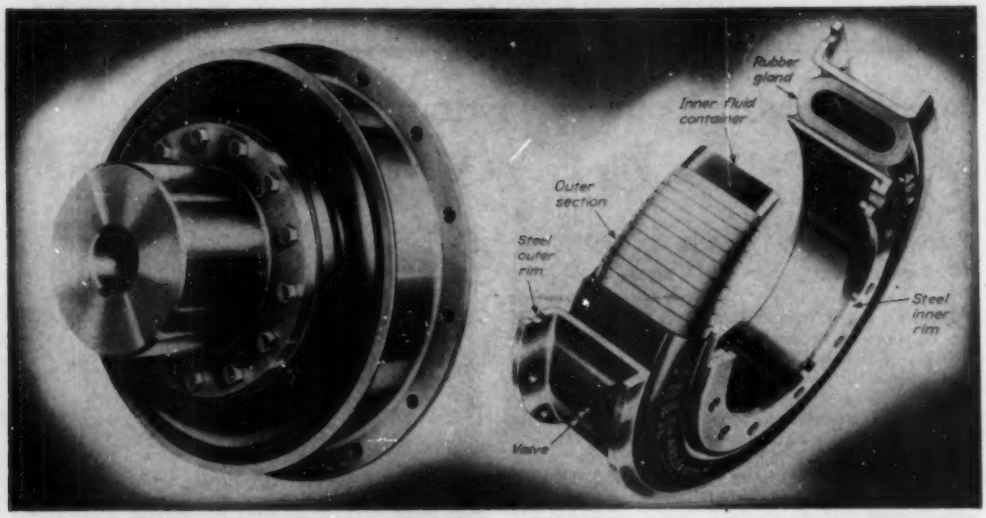
CALLED THE "JUNIOR SUPERDRAULIC", this variable control pump is made for convenient control of machine operations without variation in motor speed. Volume control is on top.



EXPLODED VIEW shows assembly of radial type plunger pump. In operation, small plungers are fitted into double row of cylinders in rotor. The plunger rollers of each bank roll against a separate elliptical reaction ring, geared to control.

CONTINUED ON PAGE 166

Coupling Cuts Torque Impact, Damps Vibration



This manufacturer's standard cushion coupling has been redesigned after ten years' service. Improvement in rubber composition and bonding have increased the torque capacity 20 percent above previously published values while the hubs and adaptors plates have been redesigned to facilitate disconnection and removal of the entire gland assembly. Redesigned components are entirely interchangeable with the equivalent components of all of the manufacturer's standard cushion couplings now in use and stand.. l parts may be combined to allow six different mounting arrangements, including flange mounting on a flywheel. Stiffness factors can be controlled and are available for torsional analysis in applications requiring vibration control.

This coupling is designed primarily for engine drives and for applications involving extremely severe torque fluctuations. Hysteresis in the rubber gland is utilized to damp vibration. No lubrication is necessary and backlash is decreased. It may be noted that electrical insulation is also provided between driving and driven machinery. The coupling can be furnished permanently filled with glycerin, or a removable cap can be supplied where air inflation is desired.

The Falk Corp., Milwaukee 8, Wis.

Flow Changes Trip Switch to Regulate Water Circuit

A new control device which responds to a flow of cold water to open or close an electrical contact has been announced. Called a "flow interlock", the device measures approximately 2½ by 3 by 7 in. In operation it closes a contact when a flow of water exceeds a preset amount and opens it when the flow falls below the preset amount. Working under this principle, the device actually acts as a fuse in a circuits which depends upon water cooling for protection.

Adjustment can be made to control the circuit for any flow from one to four gal per min. The flow differential between the cut-in and the cut-out of the electrical contact is 0.2 gal minimum and 0.4 gal maximum. The interlock does not control the amount of water flow, but this can be accomplished by installing a throttling or regulating valve ahead of the device.

The interlock mechanism is available complete with union fitting and strainer attachment. The strainer keeps foreign matter out of the housing, while the union fitting enables installation into a line and facilitates its removal for repairs or for strainer cleaning purposes.

Designed to operate for the amount of flow independent of pressure, the interlock is intended only for cold-water applications. For use with other fluids it is recommended that the manufacturer be contacted.

Electrical rating of the device is 10 amps at 125 v, 5 amps at 250 v, and 3 amps at 460 v, all ac. The flow interlock will withstand line pressure of 125 psi, maximum. Pressure drop characteristics of the unit have been tabulated up to 10 gal. per min. In this range the drop is linear. The new control device is of all bronze construction and is supplied for standard ½ in. fittings.

A special form of the unit is constructed for use with hot water, as well as a type furnished without strainer or union fitting. The manufacturer will supply information as to application on down-stream lines or for operation outside the one to four gallon range.

General Electric Co., Schenectady 5, N. Y.

CONTINUED ON PAGE 168

Just One Catalog...CRANE

Gives All the Piping Specs

To take a case in point: suppose you're designing the *Steam Generator,* shown here. What's the quickest way to find all the valves, fittings, pipe and accessories you need? Turn to your Crane Catalog. It contains the world's most complete selection of quality piping equipment . . . helps cut specifying time to the minimum.

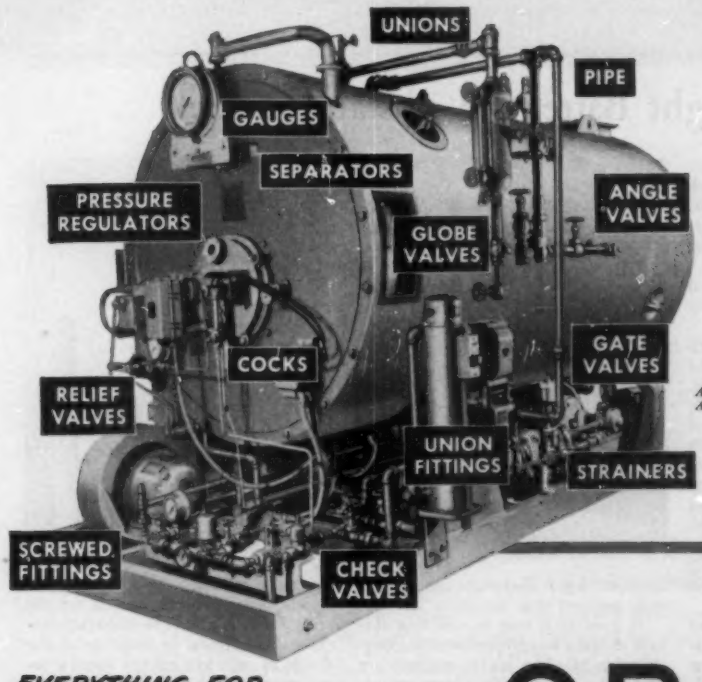
To rely on Crane simplifies all piping procedures. Ordering and storekeeping, for example, are greatly simplified when you can get everything in piping from a single source. Shop assembly goes smoother, too.

Most important to you, of course, is the added value your product acquires when all flow control equipment is Crane. Your customers know from experience that Crane Quality stands for the best in piping materials.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

FOR THROTTLING and other severe services such as blow-off, boiler feed, drip and drain lines, Crane recommends No. 16½P 150-Pound Brass Angle Valves. Crane alloy plug type disc and seat permit close regulation of flow; offer higher resistance to wire-drawing, corrosion, erosion, galling and scoring. Union or bolted bonnet, depending on size. Working pressures: 150 pounds saturated steam; 300 pounds cold water, oil, gas. Sizes: ⅛ to 3-inch. See your No. 49 Crane Catalog.

FOR BETTER SELECTION EVERY TIME
...LOOK TO THE COMPLETE CRANE LINE



Amesteam Generator by Ames Iron Works, Oswego, N. Y

EVERYTHING FOR EVERY PIPING SYSTEM

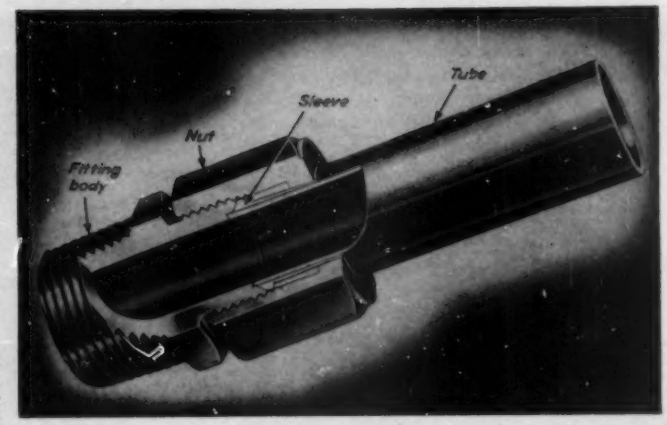
CRANE

VALVES • FITTINGS • PIPE • PLUMBING AND HEATING

Flairless Fitting Cuts Tube Distortion

This new flairless tube fitting is designed to eliminate tube gouging and limit distortion. It requires no tube flaring, permits quick installation without special tools and is ideally adaptable to close quarter connections. The gripping action of the fitting sleeve forms a positive leakproof seal and makes the fitting especially suitable for copper, steel, stainless steel, and aluminum tubing. The fitting is available in all standard shapes and sizes for tubing up to and including 1 in., OD. Many special combination shapes and sizes up to and including 2 in. can be furnished. All shapes, (elbows, tees, crosses, etc.) are machined from forgings — all other parts are machined from bar stock. The fitting meets all requirements of the JIC Hydraulic Standards for industrial equipment and AN-F-47 Specifications. Special sizes and shapes up to 2 in. can be furnished.

The Aircraft Fitting Co., 1400 East 30th St., Cleveland, Ohio



THE FITTING is composed of three parts. With the nut loose, the tube is inserted. The nut is tightened causing the tapered sleeve to engage tube on its entire outer circumference. The long bearing surface minimizes vibration and leakage difficulties. No preparatory tube flaring is necessary and the large area of sleeve contact reduces the chances for tube galling and distortion.

Lightweight Battery Withstands Shock

This storage battery, without plates or separators, is only limited in shock resistance by the strength of its plastic case, which can be selected to meet various requirments. Utilizing silver and zinc in powdered form as the active materials, the unit is from 1/3 to 1/5 the weight of storage batteries now in use.

In place of the usual acid, potassium alkali is used as the electrolite and is soaked into the active meterials. This, together with the plastic case construction, eleminates the hazards of leakage and spilling. It is also notable that corrosive and poisonous fumes are absent during charging and discharging.

The battery can be fully charged in from 10 to 20 hours and is not damaged by too rapid charging. It is also unharmed by too-rapid discharge. 2.2 volts is the maximum charge potential for all sizes.

Eight types, ranging from 0.5 amp hour to 40 amp hours are now available and larger capacity units are now being developed. Although the standard unit is unharmed by rapid charge and discharge, the manufacturer should be consulted for batteries exposed to frequent rapid discharges in the normal course of their service.

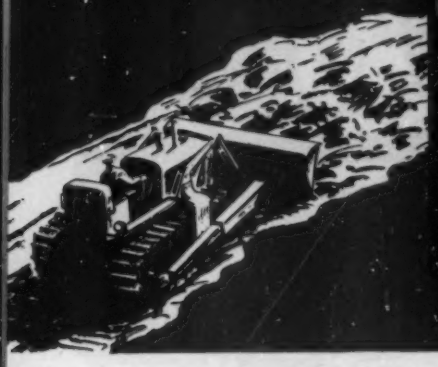
In general, it may be said that this unit in many ways resembles a rechargable dry-cell. The active materials are zinc and silver with the advantages inherent in this combination. The problem of combining these metals in a practical storage battery was solved by French technicians, and further research is now being carried out in several laboratories. The manufacturers express willingness to cooperate on the design of cells to meet any specific requirements which may be offered.

Yardney Electric Corp., 105-107 Chambers St., New York 7, N. Y.

CONTINUED ON PAGE 170

from rubble to roadway...

via



R/M

FIRST IN FRICTION

In 1949, U.S. roadbuilders completed 60,000 miles of new construction . . . a record year! Giant earth-moving units helped make this record possible; and R/M friction materials, in large measure, helped keep these units going. R/M performance, in this industry as in so many others, is the best reason for calling on your R/M representative in all problems of design and supply of friction materials.

RAYBESTOS-MANHATTAN, INC.

EQUIPMENT SALES DIVISION — **620 Fisher Bldg., Detroit 2, Mich.**

445 Lake Shore Drive, Chicago 11, Ill. — 4651 Pacific Blvd., Los Angeles 11, Calif.

1071 Union Commerce Bldg., Cleveland 14, Ohio

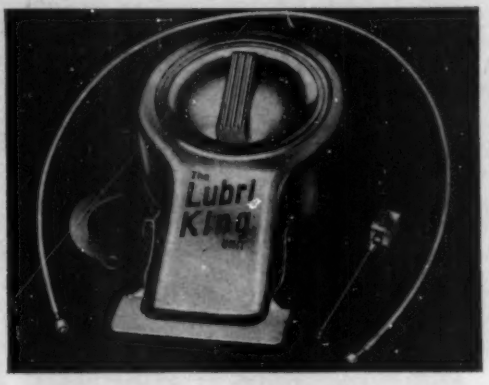
Factories: Bridgeport, Conn. Manheim, Pa. Passaic, N.J. No. Charleston, S.C.

R/M

RAYBESTOS-MANHATTAN, INC., Manufacturers of Brake Linings • Brake Blocks • Clutch Facings
Fan Belts • Radiator Hose • Mechanical Rubber Products • Rubber Covered Equipment • Packings
Asbestos Textiles • Powdered Metal Products • Abrasive and Diamond Wheels • Bowling Balls

Foot-Powered Pump Supplies Coolant for Machine Tools

This coolant supply unit, for use with machine tools, employs a foot-powered pump. The unit consists of a steel tank holding approximately two gallons of lubricant or coolant, equipped with a foot pump, 5 ft of plastic hose, and nozzle attachment with bracket that can be attached to the machine. The stroke of the foot pedal on the pump controls the amount of fluid delivered to the cutting tool, which can be as little as a few drops or a stream strong enough to wash the chips out of the taps, etc. The unit eliminates the use of oil-cans and brushes for applying lubricant or coolant. Where an operation requires a large volume of fluid, the fluid can be returned to the tank, which holds two gallons, where it is strained through a 50 mesh screen that is included as standard equipment. The unit weighs 10 lbs empty and is portable, permitting easy movement and re-attachment between machines.



W. A. Horejsi Co., Dept. PE-1, 2001 James Ave. N., Minneapolis, Minn.

Small Cylinders Save Space in Clamping Applications

This line of small air cylinders is designed for use in jigs and fixtures where size and space limitations are primary factors. With a stroke of ½ in., these units deliver 75 lbs thrust on a 100 lb line pressure. Ram pressure is maximum at any point in the stroke.

The cylinders are machined from solid brass bar stock, and consequently eliminate the possibility of rusting or pitting of the cylinder walls. Any number of cylinders may be operated by a single control valve.

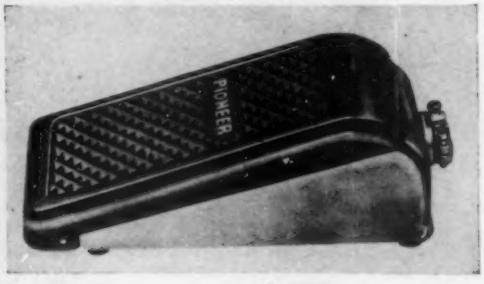
These cylinders can be used on either push or pull applications and are primarily designed for holding and clamping work for welding, riveting, drilling and general assembly. The illustration at right gives the reader a size estimate of the units.

Air-Mite, 2651 W. Lake St., Chicago 12, Ill.

Foot Switch is Readily Adaptable to Leave Both Hands Free

Shown here is a new foot switch equipped with BX clamp for BX cable, Greenfield or other direct cord. This model is rated at 12 amps 125 v or 6 amps 250 v, ac or dc. Another unit, rated at 10 amps 125 v or 5 amps 250 v, ac or dc, is furnished with heavy duty cord and plug or with a standard outlet. Both of these models are of the momentary contact type, but double-acting models, (press to start —press to stop) are also available. A mounting bracket is furnished where switch must be mounted to the floor. The standard switch is furnished in two tone gray.

These switches are designed primarily for power machines, photographic enlargers, and electrical devices where extra hand motions are dangerous to the operator and slow-up production. The standard model can be modified, or special models made, to meet product design requirements. Two special switches which are intended for use with wire and tape recorders have been designed.



Pioneer Patents and Products Co., 25 N. Franklin St., Chicago, Ill.

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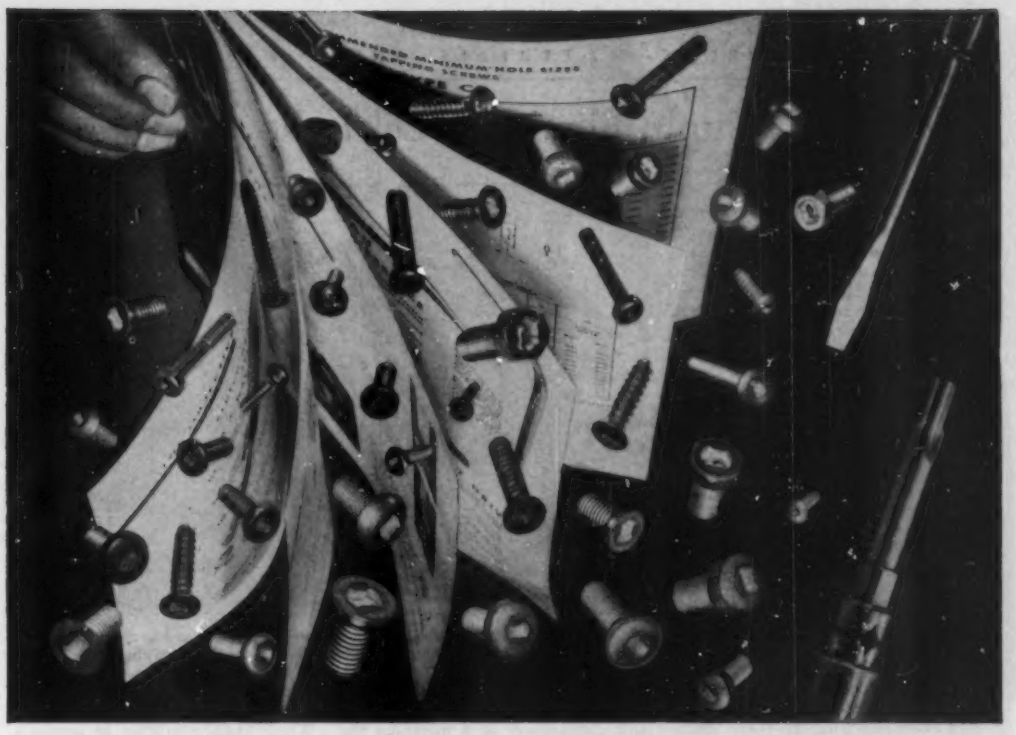


Assembly Costs Take a Tumble with Change-over to CLUTCH HEADS

Users Certify 15% to 50% Production Increases for Lower Final Costs

In view of this testimony you may confidently expect these exclusive time and cost-saving CLUTCH HEAD features to deliver a similar ratio of production increases on your assembly line . . . to lower your final costs by producing more for less.

Higher Visibility of the clutch recess eliminates operator hesitation. Even "green" help drives with speed and confidence. No "break-in" needed.

No Damaged Heads . . . Dead-center entry with the Center Pivot Column prevents driver canting, makes straight driving automatic, and checks out delay and expense fixing burred or chewed-up heads.

Now, Non-Tapered Driving that sends skid damage to zero; safeguarding manpower and material. With CLUTCH HEAD'S all-square driving engagement there is no need for end pressure to combat "ride-out" (as set up by tapered driving) and the drive home is effortless. This safety factor and elimination of fatigue steps up production.

One-Handed Reaching at "Bottlenecks." Only CLUTCH HEAD provides a frictional Lock-On that joins screw and bit as a unit to permit one-handed reaching into inner spots and driving from any angle.

214,000 Screws Driven Non-Stop. This is the record established by the rugged Type "A" Assembly Bit . . . continuous high torque driving on a main assembly line of one of America's largest automotive plants.

New Bit Life in 60 Seconds. Consider the added tool economy of simplified reconditioning this bit REPEATEDLY . . . by a 60-second application of the end surface to a grinding wheel.

Curing Field Service "Headaches." For simplified field service, CLUTCH HEAD alone has a recess that is basically designed for operation with a common screwdriver or with any flat blade which need only be reasonably accurate in width.

Those advantages are fully detailed in the New CLUTCH HEAD Brochure . . . along with technical information your engineers and plant executives will want for reference. Start your investigation of CLUTCH HEAD'S potential savings for your assembly by sending for a copy . . . and indicate sizes and types of screws which interest you.

UNITED SCREW AND BOLT CORPORATION

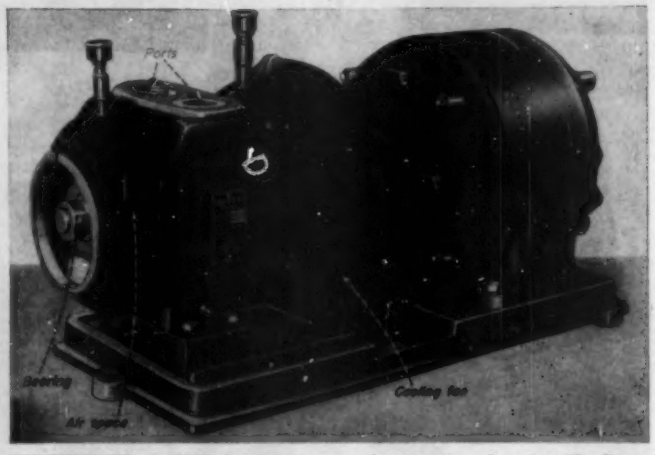
CLEVELAND 2 CHICAGO 8 NEW YORK 7

Air Pump Eliminates Oil Lubrication

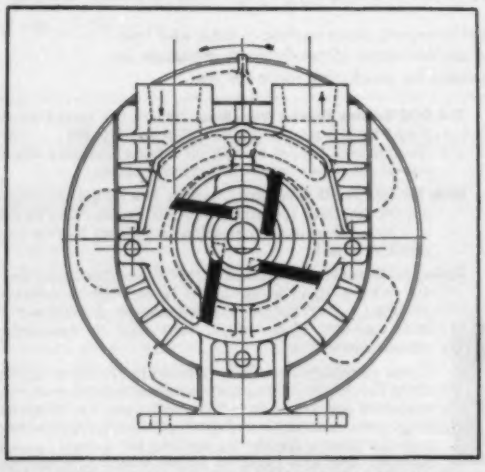
This line of air pumps is designed to eliminate oil lubrication from air pumps used for mechanical suction in order to dispense with the objection of oil vapor contamination where air is discharged in closed areas. Where air under pressure is used, the absence of oil removes the possibility of spoiling material coming in contact with the air.

To obtain these advantages, certain conditions must be accepted. These pumps are dry lubricated. The displacement blades furnish their own lubrication and take up their own wear. These blades are designed to be consumed after a reasonable length of time in continuous service and replacement costs compare favorably with the cost of oil and service time required with oil lubricated pumps over a similar period of time. Since these pumps are dry lubricated, it is essential that liquid or greasy materials be kept out of the pump. It is preferable that dusts containing abrasive matter be eliminated as this will greatly prolong the service period of the blades and avoid damaging the pump mechanism. It is consequently recommended that a dust separator be used on each pump. The use of pressure and suction relief valves is also recommended. This permits regulation of pressure and vacuum within the limits of accuracy of this type of valve which is usually well within the requirements and also reduces to a minimum the chance of overloading a motor selected for operation under specific service conditions. When one pump is used for both vacuum and pressure, the amount of air available for pressure service is limited by the degree of vacuum utilized and this double service is not conducive to close regulation. Where close regulation is necessary, it is preferable to use one pump for suction and one pump for pressure, each regulated to the desired degree of vacuum or pressure and each fitted with suction dust separator.

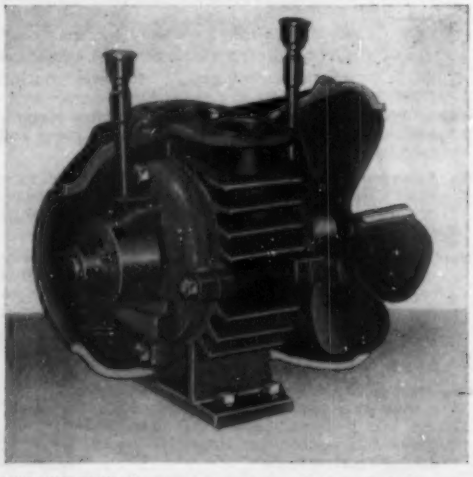
The Kraissl Co., Hackensack, N. J.



RUNNING AT 1750 RPM, these pumps are rated at 5, 10, 15 and 20 cfm. The dimensions do not vary except for the size of the ports and the discharge chamber.



NO INTERNAL LUBRICATING MATERIAL should be applied to pump. The blades provide their own lubrication.



FAN COOLED, these pumps are normally run clockwise. An air gap keeps bearing grease from working into the pump.

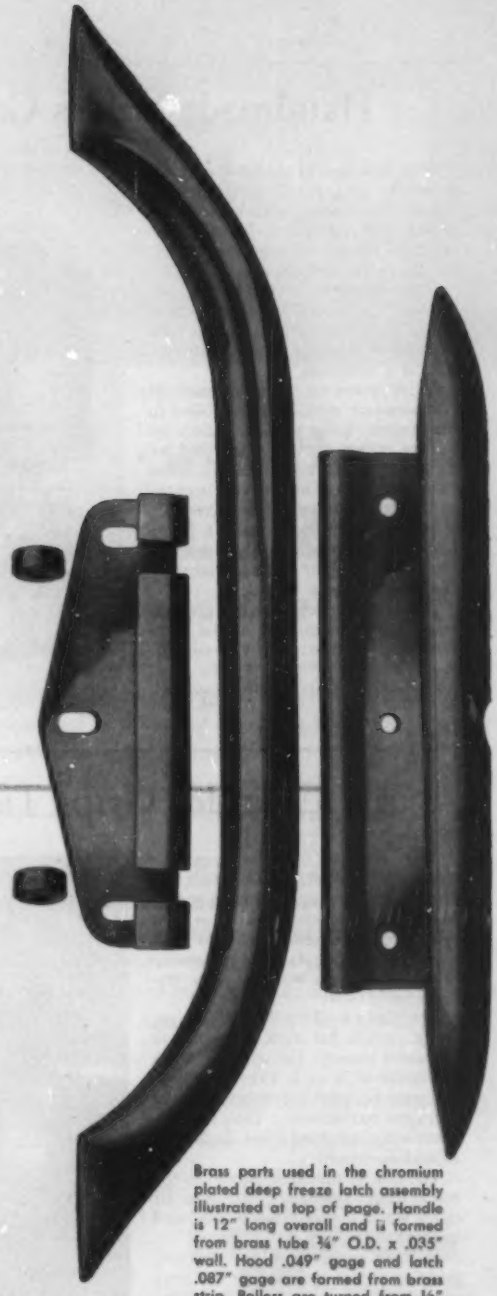
CONTINUED ON PAGE 174

SHORT, SHORT STORY:

1. Latch assembly on deep freeze cabinet was made of steel.
2. Parts rusted—plating peeled—owners complained.
3. "Covert" switched to brass—saved customer 30¢ a set.
4. Better product—no complaints—everybody happy.

IT'S AS SIMPLE AS THAT. Cost of the brass (weighing less than a pound in the finished parts) was higher. Fabricating cost and procedure were exactly the same. However, the cost of buffing the 70-odd square inches of exposed area, before plating, was cut in half and this, plus the elimination of rejected parts, effected a net saving of 30¢ per set over the extra cost of the metal.

This happened to the Covert Manufacturing Co., Troy, New York. It could happen to you. We'll be glad to talk it over. . . . Address The American Brass Company, Waterbury 20, Connecticut; in Canada, New Toronto, Ont.



Brass parts used in the chromium plated deep freeze latch assembly illustrated at top of page. Handle is 12" long overall and is formed from brass tube ¾" O.D. x .035" wall. Hood .049" gage and latch .087" gage are formed from brass strip. Rollers are turned from ½" diameter brass rod. 5007

ANACONDA

the name to remember in COPPER, BRASS & BRONZE

R.S. *Chromium plating on brass is brighter . . . less costly . . . longer-lasting*

Handmade Valves Control Liquids and Gases

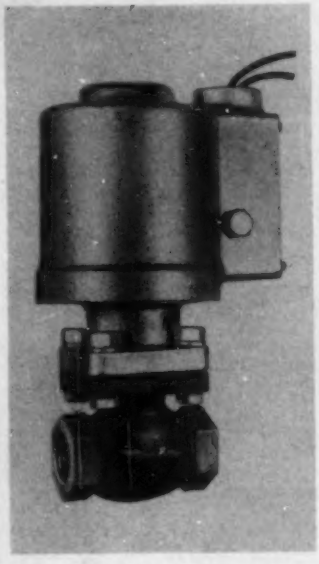
This new line of solenoid valves is especially designed for hard-to-handle liquids and gases. Handmade, the valves are engineered for precision seating. The aim has been tight shut-off and trouble-free operation.

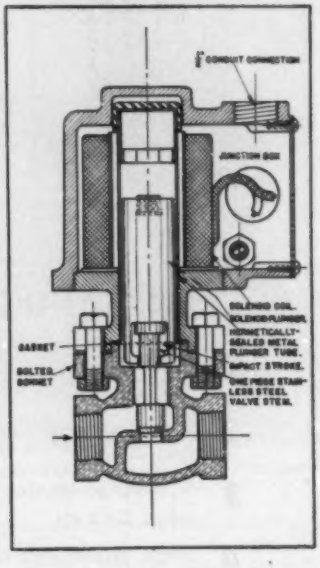
The solenoids are hand wound, moisture proof and are oversized to assure high ratio of power to friction. Laminated cores keep operating current to a minimum.

Valve bodies are heavy, are made of non-corrosive metal and are bolted to the bonnet. Valve stems and discs are in one piece and are fabricated of stainless steel. The hermetically sealed plunger tube is of high tensile strength and is non-corrosive. The valve body is joined to the bonnet with a flange and gasket to provide a tight seal, yet can be taken apart without distorting the valve body and seat.

The unit operates when the solenoid is energized, remaining in the open position until the current is cut off.

Charles Engelhard, Inc., 850 Passaic Ave., East Newark, N. J.





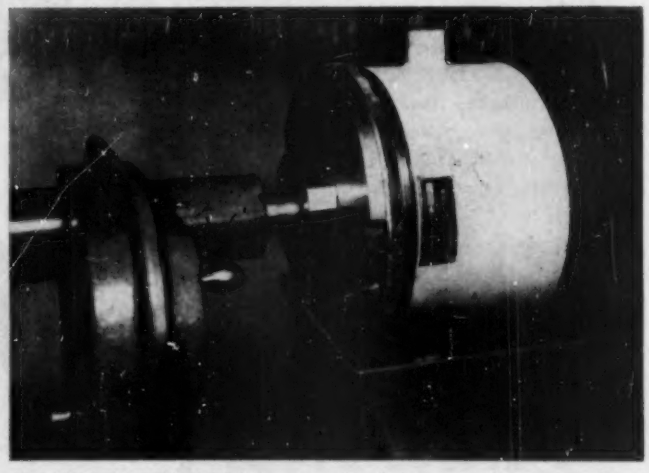
Air Cylinder Grips Tighter With Lever Action

This new air cylinder uses the mechanical advantage of levers, or dogs, to give increased gripping power. Manufacturer's tests show that this cylinder will develop three to four times the drawbar force of a conventional air cylinder with the same piston area.

The piston is of the "donut" design, which permits bar stock and work to be passed through the unit. It has a movement of ⅝ in. in either direction, and may be used for either push or pull type mechanisms. Thus it is applicable for operating collet chucks and expanding mandrels.

The unit is similar in design to the manufacturer's standard dog type air chuck which is now being widely used on production lines for chucking.

In these applications, the increased gripping power provided by the lever action of the new unit is a decided advantage. For the same force need, the new cylinder is smaller than the conventional apparatus and space-savings are possible.



THE DESIGN REFINEMENTS have been directly incorporated into the interior of the unit giving smooth exterior lines. Bar stock is shown passing through the cylinder.

Erickson Tools Div., 2311 Hamilton Ave., Cleveland 14, Ohio

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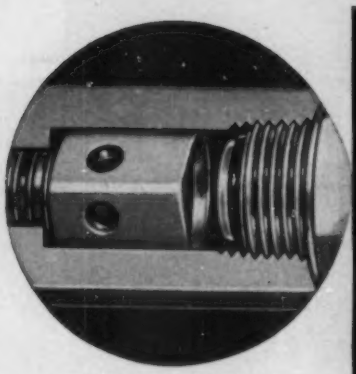
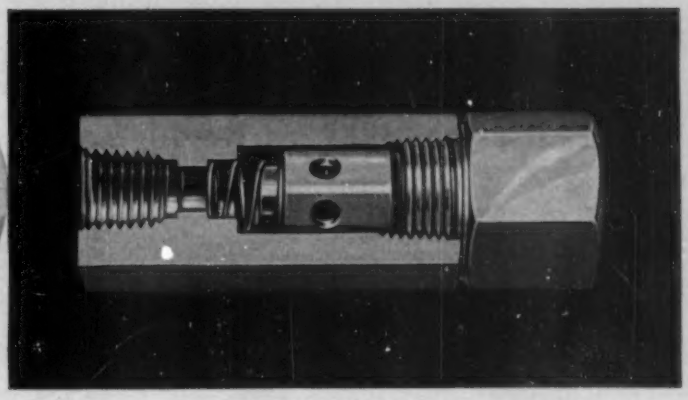


In "Open Position."



In "Closed Position."

Avoid costly air leakage . . . with this

KOHLER

Soft Seat Type Pneumatic Check Valve

Kohler K-1354 Check Valve can be furnished as follows:

Size: ⅛ ", ¼ ", ⅜ ", ½ ", ⅝ ", ¾ ".

Connection: Internal Pipe, External Pipe, Tubing, or combinations as specified.

Proof Pressure: Up to 7500 PSI.

Leakage: Zero.

Material: Brass, Aluminum or Steel.

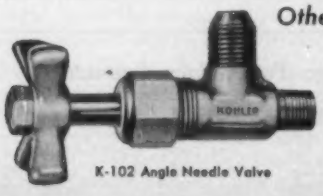
Flow: As specified.

Kohler quality valves, produced with precision workmanship, enable you to install trouble-free pneumatic systems. The K-1354 check valve is small, light in weight and versatile. By modifying the spring, opening pressures up to 100 PSI can easily be obtained.

Kohler angle needle valves, 3-way plug valves, pneumatic check valves and on-off valves will meet a variety of requirements as integral precision parts of your system.

Kohler valves, fittings and other precision parts are made in a wide range of types and sizes. Complete facilities for forging, machining and anodyzing centered in one plant help speed up deliveries and service. Kohler engineers will gladly develop valves to meet your special requirements. If you do not have a copy of our complete, illustrated Precision Parts Catalog, send for a copy today. Kohler Co., Dept. 25-U, Kohler, Wisconsin. Established 1873.

Other Kohler Precision Valves for Pneumatic Systems



K-102 Angle Needle Valve

K-2001 On-off Valve

K-703 3-way Plug Valve

KOHLER OF KOHLER

PLUMBING FIXTURES • HEATING EQUIPMENT • ELECTRIC PLANTS • AIR-COOLED ENGINES

Pressures to 5000 psi Regulated By Hydraulic Pump

Pumps are of axial piston type. Units offered in capacities of 55, 110 and 165 gallons.

This new line of oil-hydraulic pumping units is designed for regulative pressures up to 5000 psi. These high pressure units are available in 22 models designed to specifications recommended by the Joint Industry Conference, Hydraulic Standards for Industrial Equipment.

A reservoir base, with all operating components, including pump, relief valves, gauges, and electric motor drive, mounted on the removable top cover, make up each unit. The compactness throughout is an important advantage in obtaining sufficient power for many types of modern machinery, without penalty of excessive bulk.

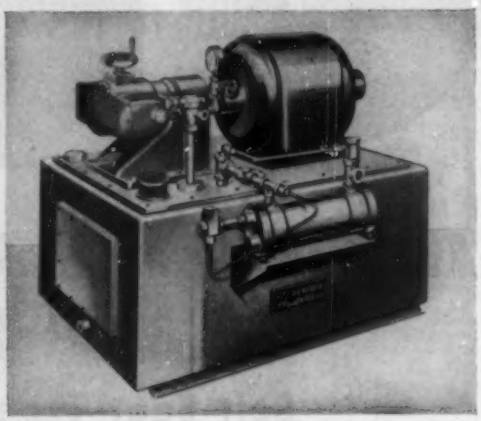
Supplied in capacities of 55, 110, and 165 gallons, the reservoir of these high pressure pumping units is of welded steel construction and has an access door at the end to simplify tank cleaning. Bottom of the reservoir is above floor level, and it slopes slightly to facilitate draining.

Three series of dension hydraulic pumps are offered. These are of axial piston type and may be for either constant or variable volume. The 600 series pumps delivery up to 9 gpm at 1800 rpm in a pressure range up to 5000 psi. Pumps of the 700 series are rated at 20 gpm at 1200 rpm for requirements up to 5000 psi. The 800 series provide a maximum 35 gpm at 1200 rpm for service up to 5000 psi. The variable volume pumps are available with a choice of handwheel, pressure compensating, stem or cylinder control of oil delivery. The constant displacement pumps are basically of the same design and construction, exclusive of the controls. In addition to compactness, other features of dependability and quiet operation are reported to suit these pumps especially for industrial installations. The pump and electric motor are mounted horizontally on the reservoir cover plate and connected by a flexible coupling.

Within desired range up to 5000 psi, accurate adjustment of pressure can be made with the relief valve, which is the Denison threaded body type. A knurled adjustment knob is provided on the valve cap. Pressure gauge and gauge shut-off valve are connected directly to the relief valve and used for initial setting of system pressures.

Optional equipment is available to extend the versatility of these high pressure oil-hydraulic pumping units. For example, a heat exchanger attachement can be provided for cooling oil in the hydraulic system, and a vacuum gauge added to permit checking condition of the oil filter within the reservoir at any time.

The oil cooler consists of standard 2-pass heat exchanger, complete with thermostatic control that automatically starts and stops coolant flow at desired temperatures. Water is used as the coolant. Temperature at which the oil cooler becomes operative is adjustable. The oil cooler is recommended for installations where the pumping unit is operated at 50 per cent or more of maximum pressure, or for 10 per cent or more of the total cycle time. A bypass circuit and low pressure relief valve protect the heat exchanger from sudden surges of pressure or flow. A dial indicator temperature gauge is also available to indicate temperature of oil within the reservoir.



MOTOR AND PUMPING UNIT are mounted on top of the reservoir with access to pressure regulating units and adjustment controls. Compact construction of the welded steel reservoir as shown clearly, with cleaning access door at left.

It is difficult to establish how often the oil filter should be cleaned, as conditions vary with each unit installation. The optional vacuum gauge simplifies timing this important maintenance function. With the vacuum gauge, the need for oil filter cleaning is plainly indicated. When the gauge shows a reading of 10 in. mercury at 100 deg F, the filter is dirty or clogged and should be cleaned. Maintenance is usually sufficient, using the vacuum gage.

Denison Engineering Co., 1171 Dublin Rd., Columbus 16, Ohio

Miniature Power Supply Gives High Voltage For Geiger Counter

This miniature high voltage power supply for use with military and civilian Geiger counter equipment has recently been announced.

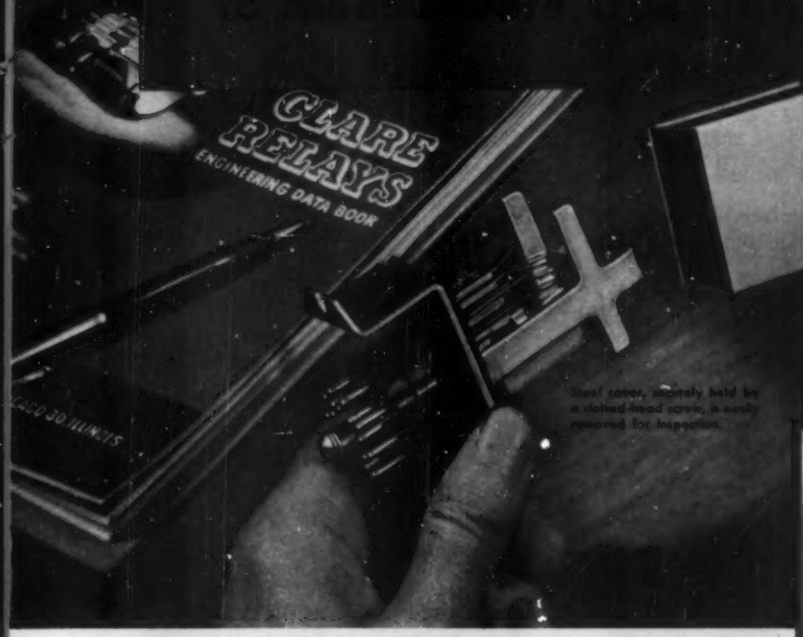
The model offered is a hermetically sealed unit. It operates from a 3 volt nominal battery and delivers a regulated and filtered output of 900 volts dc. The unit measures 1⅝ by 2 $\frac{5}{16}$ by 2¾ in. and weighs only 12 ounces. The output voltage is constant within one percent for an input battery voltage varying from 2.2 to 3.5 volts and the output ripple is less than 0.2 volts. This model is available for fixed or plug-in mounting and has a life expectancy claimed by the manufacturer to be more than 1,000 hours.

The power supply employs a four-pole vibrator used in a self-rectifying voltage multiplier circuit. Outputs range to 5 watts and up to 2500 volts.

Eltron, Inc., Jackson, Mich.

CONTINUED ON PAGE 178

CLARE TYPE "J" TWIN CONTACT RELAY



Steel cover, securely held by a slotted-head screw, is easily removed for inspection.

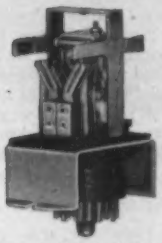
● This new CLARE dust-tight plug-in enclosure for the small Type "J" Relay offers designers a number of unusual features for installation on industrial equipment.

Entrance of dust is prevented by the steel cover and by use of a Neoprene gasket which is closely fitted at the factory to the relay terminals. The dust-tight cover is easily removed for inspection. Use of standard radio plug simplifies installation and cuts wiring costs. Base is secured to chassis to prevent plug from being jarred or accidentally pulled from its socket.

Exclusive design of the CLARE Type "J" Relay allows the twin contacts to operate independently of each other. One contact is sure to close, reducing contact failure to the practical limit. This relay combines all the best features of the conventional telephone-type relay with small size and light weight. It provides unusually high current-carrying capacity, large contact spring capacity, extreme sensitivity and high operating speed.

This new dust-tight enclosed relay is one of many outstanding CLARE contributions in the development of new and better relay components for industry. CLARE Sales Engineers are located in principal cities to consult with you on your relay problems. Call them direct or write: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. Cable Address: CLARELAY. In Canada: Canadian Line Materials Ltd., Toronto 13.

Write for Bulletin No. 108



Neoprene gasket, closely fitted at factory to relay terminals, between base and cover, effectively occludes dust.

Plug is standard radio-type plug. Standard finishes are silver lustre lacquer for cover, cadmium for base. Retaining screws hold base securely to panel.

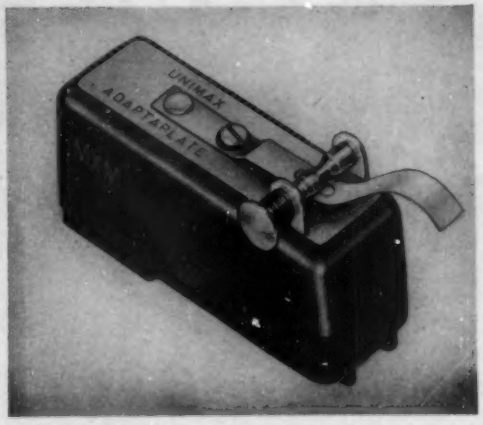
CLARE RELAYS

Switch is Restored to Safety After Manual Latch-In

This new safety interlock for high-voltage equipment is built so that the electric circuit can be manually reclosed for testing, with no danger of being found "hot" later.

The mechanism consists of two elements. The first is a conventional leaf-type actuator for opening the switch contacts when the door or access panel of the protected enclosure is opened as little as ⅛ in. The second is a push-button-operated slide cam mounted above the leaf actuator so that the interlock circuit is reclosed when the button is pushed. A detent in the slide cam engages the leaf actuator to keep the switch contacts closed while the circuit is being worked on.

The switch is restored to "safety" by light pressure on the leaf actuator. This releases the dentent of the slide cam which is then moved back to its off position by a spring. If the service man neglects to restore the interlock to "safety", the action is accomplished automatically as soon as the door is closed. Use of this new safety switch avoids the hazard introduced when service men tie down, block, or jump out conventional interlock switches.

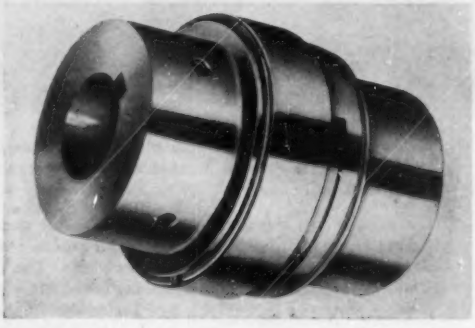


Unimax Switch Division, The W. L. Maxson Corp., 460 W. 34th St., New York 1, N. Y.

Coupling Has Two-Part Sleeve for 50 to 1000 HP

For use in the 50 to 1,000 hp range, this coupling uses an inside sleeve made in two parts—providing a sleeve in each body. With both sides machined alike, the removable collar can be put on either half. The collar is held in place by a snap ring.

Except on reversing load, half the cushions are idlers. This provides a reserve supply of these cushions which are interchangeable and are always in sight. No lubrication is required and the metal jars are not subject to wear. Cushion material is supplied to suit the application. In one application, oil resisting neoprene, protected by bronze, is employed for use when oils, chemicals, ozone and heat conditions would deteriorate ordinary cushion material.



Lovejoy Flexible Coupling Co., 5001 W. Lake St., Chicago 44, Ill.

Casing Protects Push-Pull Controls With Vinyl or Stainless

Two new types of casing, used primarily for push-pull controls, recently have been announced. The first type consists of a high-strength bronze flat-wire casing completely enclosed by a water-tight tough vinyl cover, the principal size having an overall diameter of ¼ in. Advantages reside in the small inside diameter (.095 in.) of the casing that closely fits the control wire (.072 in.), causing less "lost motion" between the two parts. The flat-wire construction provides a smooth inner surface for control wire, and by making a solid wall construction, produces a casing having at least 15 percent more bend resistance than a similar-sized round-wire construction. The vinyl cover is not harmed by salt water, greases, gasoline, and most other chemicals.

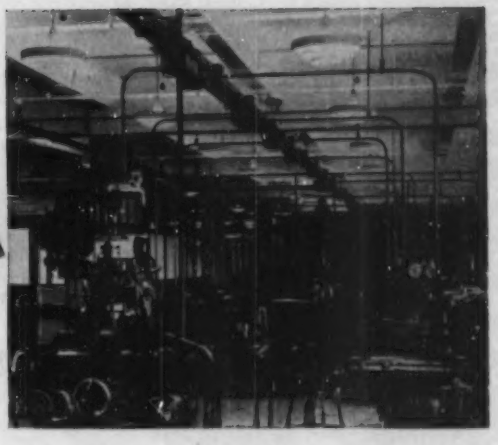
The second new type casing is made of stainless steel wire, the strength of which is approximately double that of brass or bronze. Made primarily in ¼ in. OD with large, strong, control wire and thick wall (both .072 in. wire), this casing is the strongest available in any popularly-known corrosion-resistant alloy. The stainless steel safely withstands the corrosive action of most industrial chemicals. On marine applications, monel metal wire is somewhat more resistant to the action of salt water, although stainless steel is substantially stronger.

Kupfrian Mfg. Co., 350 State St., Binghamton, N. Y.

CONTINUED ON PAGE 180

Cold-Formed Shapes

USED IN Industrial Power Systems



This cold-formed shape, a 7-in. channel with 1-in. legs, is used as a housing member by Trumbull Electric, a manufacturer of plug-in systems for the distribution of industrial light and power. We make it on brakes, using 16-gage steel, and furnish it to the customer in long lengths.

Housing-members for power systems . . . bases for milk cans . . . sills for freight elevator doors . . . parts for ornamental railings . . . hatch covers for seagoing vessels . . . there's virtually no limit to the possibilities of Bethlehem Cold-Formed Shapes. In fact, so versatile are these economical shapes that new uses are continually being discovered — some of them so unusual that they come as a surprise even to us.

Bethlehem Cold-Formed Shapes are made from strip, sheets or plates. They are uniform in thickness, practically free from scale, and have an excellent strength-weight ratio. They are furnished in all gages from 7 to 24, inclusive.

Perhaps there is a job in your own plant in which the use of Bethlehem Cold-Formed Shapes could save both time and money. Why not let us look into it for you? To start the ball rolling, we suggest that you get in touch with the nearest Bethlehem sales office. Or, if you prefer, write to us at Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

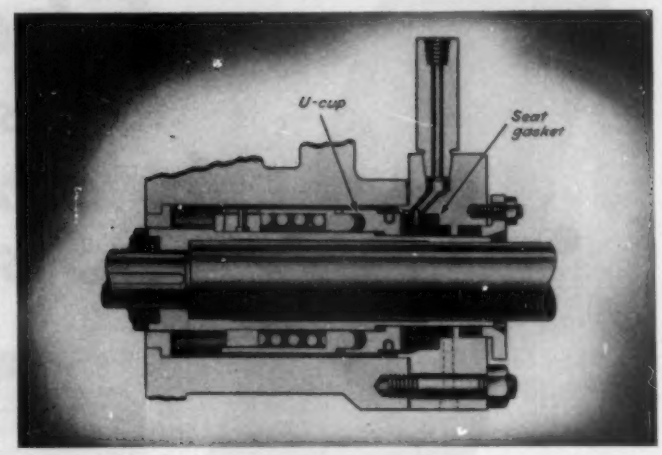
Mechanical Seals Fit Present Pumps

Designed for sealing stuffing boxes in the manufacturer's line of centrifugal pumps, these mechanical seals can, in many cases, be used on units now in service. Reduced leakage and lower maintenance are claimed, together with freedom from adjustment difficulties at and after installation. Three types are available:

The type U, a balanced high pressure single seal, is for shaft sizes from 1¼ to 5⅞ in. The stationary face, protected during handling and installation by a cover is, in most cases, constructed of carbon. Leakage around this stationary face is prevented by a seat gasket, while a U-cup holds leakage under the rotating face. The material used for these seals will vary with the service.

The type L, for shaft sizes not exceeding 2 in., is designed as a more economical seal for temperatures below 110 F and pressures under 50 psi.

The type B, an oil lubricated, double seal, is designed for higher pressures on non-lubricating liquids.



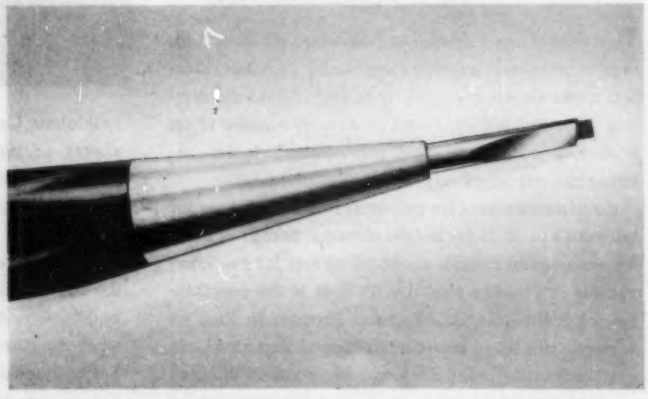
THIS CUTAWAY VIEW of a centrifugal pump shaft shows the assembly of the balanced, high pressure single seal. Primarily designed to increase service time, manufacturer's tests show reduced leakage loss of product with the new seals.

Byron Jackson Co., Pump Div., Terminal Annex Box 2017, Los Angeles 54, Cal.

Pencil Draws Without Sharpening

This draftsman's pencil is equipped with a thin, flat lead, which is almost flush with the outer steel sleeve when in use. Lines are drawn with the pencil tilted slightly from the vertical. The sleeve protects the lead and keeps graphite dust from the drawing edges. The paper is contacted by the sleeve as well as the lead. As the lead wears, the sleeve automatically retracts, requiring no adjustment until approximately 0.2 in. of lead has been used. Then the pencil shaft is turned, until the sleeve has advanced with the lead to its fully extended position. Leads are replaced in a manner similar to that used with conventional mechanical pencils.

In use, this pencil needs only occasional adjustment of the lead, and there are no interruptions for sharpening or pointing. Leads are furnished in two widths, 0.30 mm (0.012 in.) and 0.45 mm (0.018 in.) and in HB, H, 2H and 4H hardness grades. Since the line drawn is the same width as the lead, lines of constant width can be drawn continuously without adjust-



THIS SWISS MECHANICAL DRAFTSMAN'S PENCIL is now being offered in the United States. The steel sleeve covers the lead and protects it from breakage. For illustrative purposes the lead is here shown extended somewhat more than it would be while being used, when the lead and its protective sleeve are almost exactly flush. Costs of the new pencil are roughly comparable to those of conventional units.

Evenline Products, P. O. Box 47, East Side Station, Providence, R. I.

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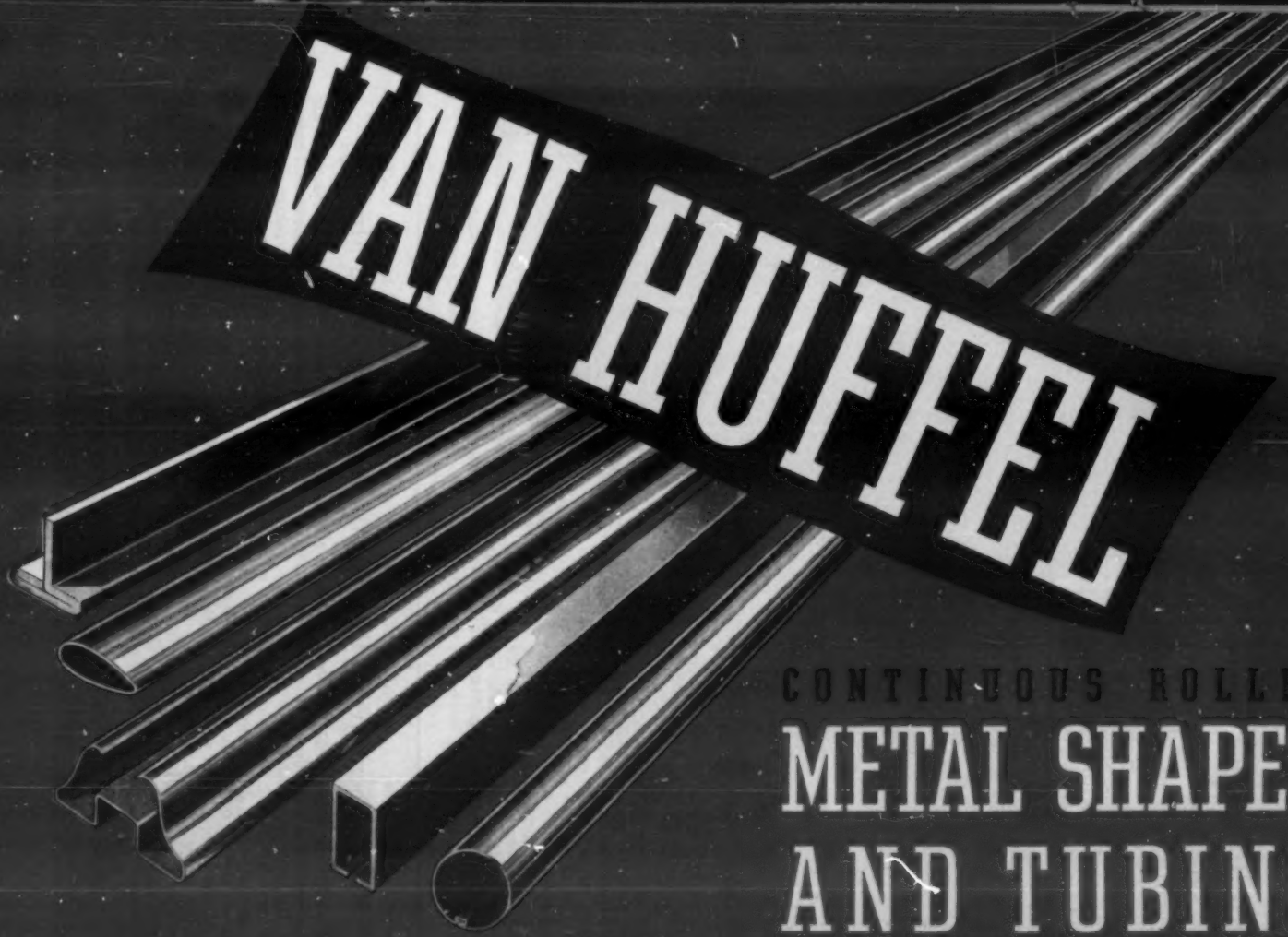
VAN HUFFEL

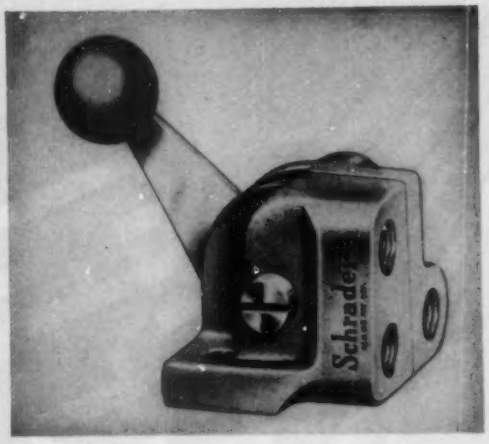


CONTINUOUS ROLLED

METAL SHAPES AND TUBING

VAN HUFFEL TUBE CORPORATION · WARREN · OHIO

Forged Brass Valve Fastens With One Bolt



This forged brass operating valve uses a lapped stainless steel disk, sliding on a bronze ring, to provide sealing action. Held together by one bolt, the unit is pointed toward parts simplicity and ease of replacement. With ⅛ in. ports, the capacity at 100 psi is 10 cu ft of free air per minute. Adaptable to cylinders up to 3½ in. bore in short strokes, the valve is available in two, three and four way types with a hand or mechanical lever, suitable for hand, foot, knee, or mechanical actuation. Actual dimensions of the body of the valve are 1⅝ by 1¼ in.

These valves are suitable for machine mounting to give automatic operation by means of linkage. The manufacturer states the units will stand up under continuous machine actuation.

A. Schrader's Son Div., Scovill Mfg. Co., Inc., 470 Vanderbilt Ave., Brooklyn 17, N. Y.

Light Pressure Operates High Speed Foot-Switch

This new, large treadle foot switch is operated by light toe pressure at any point on the inclined face. Requiring a ⅜ in. throw to trip its snap-action switch, the unit is designed for high speed operations where fatigue is to be avoided. Styles are available for BX connection or for use with portable rubber cord.

Capacity ranges from 20 amps at 125 v, ac, to 15 amps at 250 v, ac. From 230 v to 460 v, ac, the switch will handle ½ horsepower.

Contact arrangements include single-pole single-throw normally open, single-pole single-throw normally closed, and single pole double throw. Access to wiring terminals is by removal of the rubber, floor-grip base.

General Control Co., 1200 Soldiers Field, Boston 34, Mass.

Relay is Sensitive to 0.012 Watts in Open or Sealed Models

This sensitive relay is available in either an open or hermetically sealed model. The single pole, double throw unit is sensitive to 0.012 watts, dc, while the double pole, double throw unit is sensitive to 0.55 watts, dc. These can also be supplied for ac use. The coil is acetate insulated, bobbin or layer wound, with a maximum resistance of 12,500 ohms.

Silver contacts are used for a 1 amp, non-inductive load at 24 v, dc; or 115 v, ac. Armature contact is at the frame potential. Mounting is by one hole with a locating lug. The units are also available with dust covers or hermetically sealed, and with plug-in or solder terminals.

The dimensions of the open relay are 1⅛ by 1 7/16 by 1⅝ in. The sealed relay is 3 3/16 in. long, including the sealed plug, by 1⅛ in. by 1⅛ in. high. Standard weight is 2.5 oz, while the hermetically sealed unit is 4.5 ounces.

In special applications, relays sensitive to 0.003 watts SPDT or 0.012 watts DPDT can be obtained. Palladium or other precious metal contacts for audio or low voltage circuits, and tungsten or other alloy contacts for higher current or voltage circuits are also available. Another special unit gives maximum input of 4.0 watts at 20 deg C for an 85 deg C raise.

This unit is identified as an S relay. A number of additional relays will shortly be announced.

Allied Control Co., Inc., 2 E. End Ave., N. Y., N. Y.

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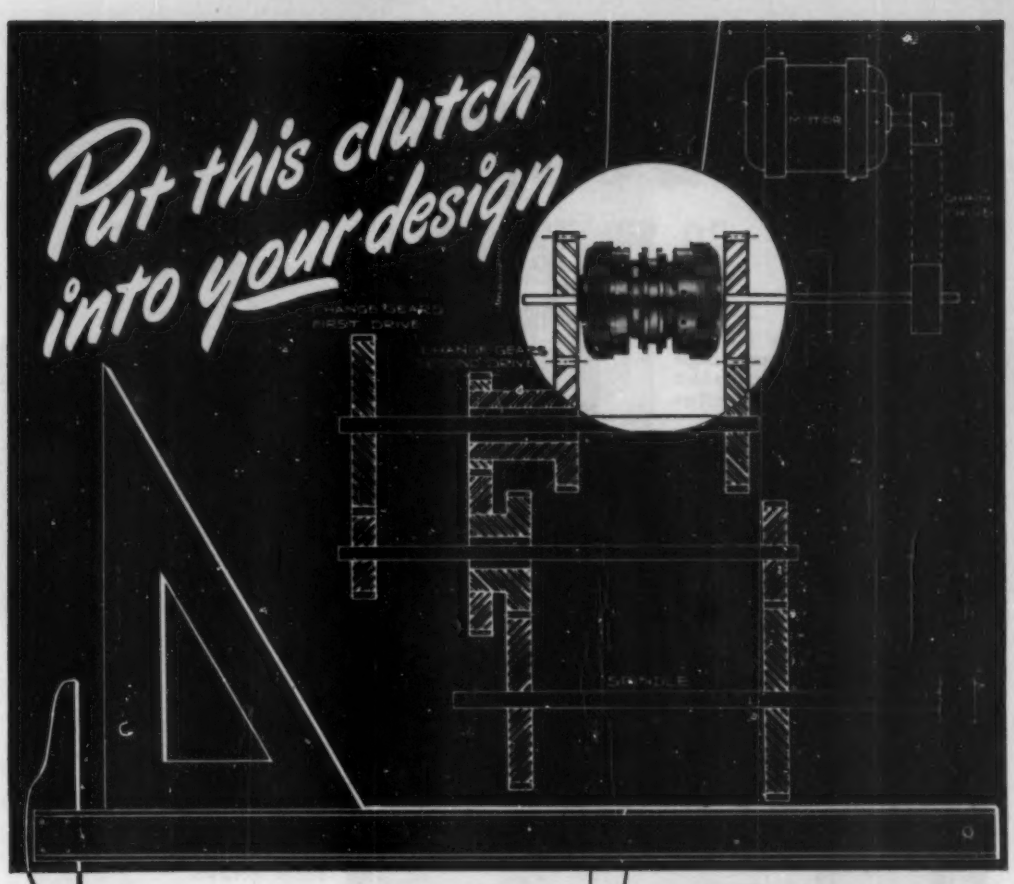


Twin Disc Machine Tool Clutches are engineered to fit easily into your design. They can be used as primary or cut-off clutches or as clutches that control a given function during continued operation . . . such as change-of-speed clutches where frequent operation is required.

These compact Twin Disc Clutches have exceptionally high torque capacity compared with the relatively small space required for installation. For example, a 5.5″ Twin Disc Oil-type MTS Clutch with seven driving plates has a working torque capacity of 3200 inch-pounds.

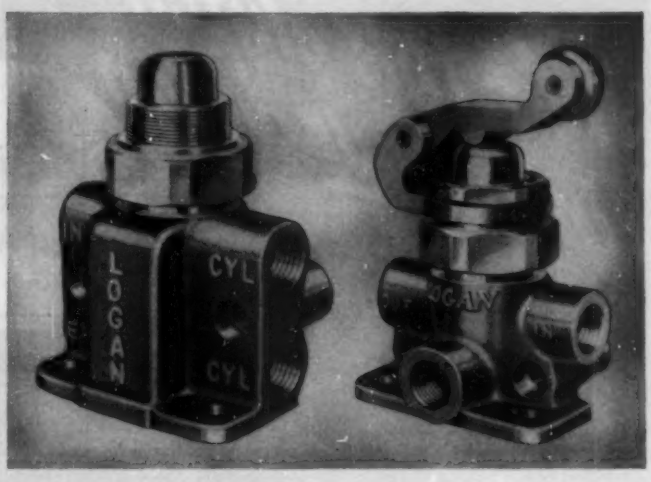
This high torque capacity is obtained through use of materials with high friction coefficient . . . ample number of friction surfaces . . . a quick and easy method of removing oil from between the friction surfaces.

Twin Disc builds both oil and dry type Machine Tool Clutches . . . single and duplex construction . . . sizes from 3″ to 12″. For complete information write for Bulletin 134-A.

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

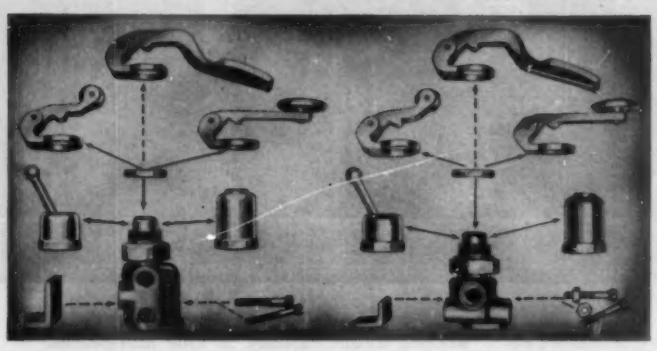
SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

Basic Valve Is Easily Modified



These two new lines of ¼ in. port air valves are each based on a single valve body. Additional parts are added as illustrated to form the other valves of the series.

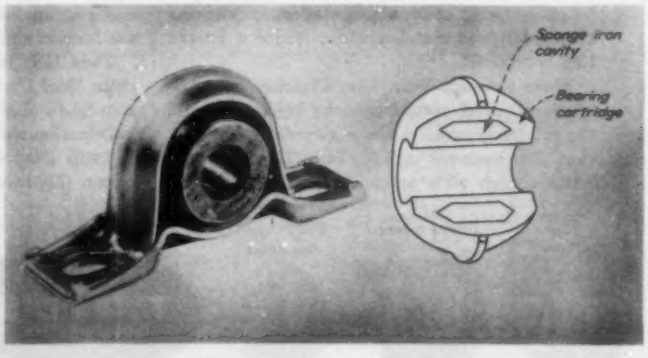
Balanced piston construction gives ease of operation, without valve seats or rod packings to become worn. The piston assembly is removable as a complete unit. Designed to be self cleaning, these valves are furnished with all parts corrosion resistant.



Above: At the right the final set-up of the 3-way cam valve is shown. With center part plugged, these units are suitable for many open-shut operations. Also pictured is the push button model in the 4-way, 2-position series. Left: Assembly of the 3-way valve series is illustrated on the right. To the left is the 4-way series. These can be used for remote control of pilot operated master cylinders or converted to 3-way valves by plugging the center parts. The valve can be used for push-button operation.

Logansport Machine Co., Inc. Logansport, Ind.

Pillow Block Is Self Lubricated



Available in bore sizes of ½, ¾, ¾, and 1 in., this bearing retains its supply of lubricant in a special cavity filled with sponge iron as well as in the pores of the entire bearing cartridge. By impregnating the metal with the correct lubricant, under pressure, the manufacturer has designed this unit to provide a protective coating around the shaft without dripping. Manufacturer's tests show a life expectancy of 20,000 to 30,000 hours under normal operating conditions. Maximum recommended speed is 4000 rpm.

Congress Drives Div., Tann Corp., 3750 E. Outer Dr., Detroit 34, Mich.

CONTINUED ON PAGE 186

Announcing

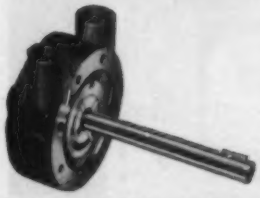
A NEW SERIES OF

AUTOMATIC REVERSING VANE PUMPS

Nos. 8021, 8061, 8101 — and

Stripped Models with Housings

Stripped Models without Housings



Stripped Models with Housings, Nos. 8022, 8062 and 8102. Simplify installation, particularly where internal discharge and suction ports are not readily incorporated in the machine design, or where outside piping is desirable.

Stripped Models without Housings, Nos. 8023, 8063 and 8103. Made for manufacturers who wish to utilize pumps as integral parts of machines with suction and discharge ports incorporated in the machine castings. Provides compact installation... minimum projection from machine surfaces.

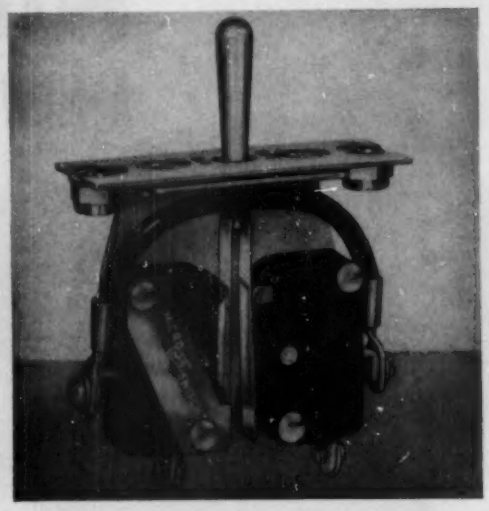
Many important and convenient features have been designed into this New Series of Brown & Sharpe Pumps for lubrication and coolant systems on machines that reverse. Heading the list is the fully-automatic reversing feature with unidirectional flow. Other features include... three sizes—2½, 5 and 11½ gpm at 0 pressure, max. speed 1140 R.P.M.... easy changeability of flow direction from one port to the other, in the field... mounting design that permits foot to be set in 4 different positions with ports held vertical.

For integral mounting, each size pump is furnished also as a stripped model *with* housing, or stripped model *without* housing. Easily installed with minimum number of machining operations. Complete information available in new Bulletin. Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

We urge buying through the Distributor

BROWN & SHARPE PUMPS B·S

Double Throw Switch Has Special Circuit Set-Up



This three-position, momentary contact switch consists of a self-centering toggle lever with one normally open and one normally closed switch. A jumper wire connects the common terminals of the units. Operation of the toggle lever will either open the normally closed switch or close the normally open switch. Travel is 25 deg from center on either side. The unit has a total weight of approximately 2 oz and ratings of 10 amps, 125 to 250 v ac; 10 amps, 28 v dc, non-inductive; and 6 amps, 28 v dc, inductive. An alternate unit provides two double throw switches.

In the illustration, the toggle lever is at the center position, the normally open switch is open and the normally closed switch is closed. Operating the toggle lever to the right closes the normally open circuit of the one switch. Operation of the lever to the left opens the normally closed circuit of the other switch, leaving both circuits open.

Micro Switch, Freeport, Ill.

One Instrument Reads Current, Resistance, Capacity and Potential

Measuring 13¾ by 16¾ by 7 in., and weighing 18½ lbs, with a rating of 115 volt-amps, this instrument is designed to measure resistances to 1/10 ohm and capacities to 1 mmf. Peak to peak voltage measurements can be taken, and a zero-center dc scale is also included. Ac range is 1,200 v. Probes and test leads are furnished with the instrument. The meter scale is 9 in. square and the entire unit is enclosed in a portable steel carrying case, to increase the speed and ease of taking readings.

Hickok Electrical Instrument Co., 10544 Dupont Ave., Cleveland 8, Ohio

Pressure Transmitter Withstands Corrosion

Designed for use with corrosive mediums such as red fuming nitric acid, this new electric pressure transmitter employs four active 300 ohm bonded strain gages arranged in a Wheatstone bridge circuit. It is available in ranges from 100 to 5000 psi. Powered by a maximum voltage of 18 volts, the instrument produces a full scale output of 50 millivolts open circuit. The output is linear with pressure and its repeatability is better than ¼ percent of full scale. The instrument is temperature compensated for zero shift and sensitivity change with temperature. Zero shift in standard units will not exceed 0.01 percent of full scale per deg F change and sensitivity will not change more than 0.01 percent of reading per deg F change. The undamped natural frequency of this transmitter is over 1,500 cps, depending upon the range. The overall dimensions are 3¼ in. in height and 3¾ in. in diameter. Its weight is approximately 30 ounces, without leads. Applications are expected in guided missile and rocket research development.

Fredric Flader, Inc., 583 Division St., North Tonawanda, N. Y.

CONTINUED ON PAGE 188

Dayton Cog-Belts*

take a bite out of costs

Here are the ways a designer of a V-Belt-driven product takes a big bite out of costs by belting with Dayton's patented, premium Cog-Belt—

His equipment, driven, say, by a 7-belt 40 H.P. "C" section drive, is handled by only 5 Dayton Cog-Belts, while 10 pulleys do the work of 14. Total saving in cost of drive: 17%!

The product now costs less to ship—drive weighs 28% less, is 47.2% more compact. It performs better because Dayton Cog-Belts, "Built to bend" like the joints of your finger, withstand starting and shock loads better, last years longer.

To add the advantages of a Cog-Belt drive to your product, write for engineering data. Remember—only Dayton has the Cog-Belt—it's *patented* and *exclusive!*

DAYTON RUBBER COMPANY, DAYTON 1, OHIO

* T.M.

Here are the advantages of using premium
DAYTON COG-BELTS

40% MORE H.P.
FEWER BELTS
SMALLER PULLEYS
LONGER LIFE

V-Belts by Dayton Rubber

WORLD'S LARGEST MANUFACTURER OF V-BELTS

New Strain Indicator Increases Accuracy of Gages

This portable battery-powered strain indicator is designed for use with the manufacturer's bonded resistance wire strain gages. Improvements have been announced over the previous instrument.

With accuracy unaffected, the ten "Thousand" steps are increased from 1,000 to 2,000 microinches per inch per step. The Range Extender has been increased to 20,000 microinches with an accuracy claimed within plus or minus 50 microinches. This extends the balancing range of the instrument to 30,000 microinches, permitting measurements in the plastic range of metals.

The instrument can also be used with a completely external Wheatstone bridge, while another feature allows for connection of an oscilloscope for applications in re-phasing problems encountered with long leads between the strain gage and the instrument. This also allows for limited dynamic studies because of connection into the amplifier section of the instrument which permits pre-amplification of the strain gage signal for readings on a standard oscilloscope.

Measuring accuracy has also been improved. The "Thousands" steps have a tolerance of plus or minus 2½ microinches per inch. Slide wire tolerance is plus or minus 5 microinches per inch and the Gage Factor adjustment is accurate to plus or minus ¼ percent at any point.

The instrument is designed and calibrated for 120-ohm gages with gage factors of 1.77 to 2.20. However, gages of other resistances and gage factors may be used if necessary. An ac-dc converter is available for operating the indicator on 110 v, 60 cycle, single-phase electric power when required for continual operation. The instrument weighs about 25 lb with batteries.

Baldwin Locomotive Wks., Philadelphia 42, Pa.

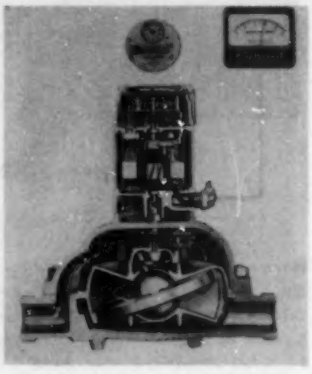
Meter Unit Controls Flow of Corrosive Liquids

This unit, composed of a meter and a control mechanism is used to indicate and control the flow of corrosive liquids.

The meter indicates the rate of flow at all times and at the same time totals every gallon on its register. Measurement is volumetric. Each complete movement of the measuring piston displaces a fixed volume of liquid. The liquid enters through the inlet port and fills the spaces above and below the piston. The volume of liquid flowing in the annular space around the center ball of the piston causes the piston to move with a "nutating" motion until the liquid discharges through the outlet port. The center port of the piston is thereby caused to make a circular motion which is transmitted through a gear train to the drive shaft which passes through the stuffing box to the direct connected generator through a self-aligning coupling. The rate of flow indicator (which can be mounted remote from the rest of the meter) measures the out-put of the generator and is calibrated to indicate the corresponding rate of liquid flow through the meter.

The control mechanism is set at the rate of flow desired. It will then hold the flow at that setting and in addition will indicate and integrate the flow.

The entire unit is composed of the meter plus the control. The output of the meter generator operates a control valve to change the rate of flow until generator output is balanced on the rate-of-flow potentiometer.



The Hays Corp., Michigan City, Ind.

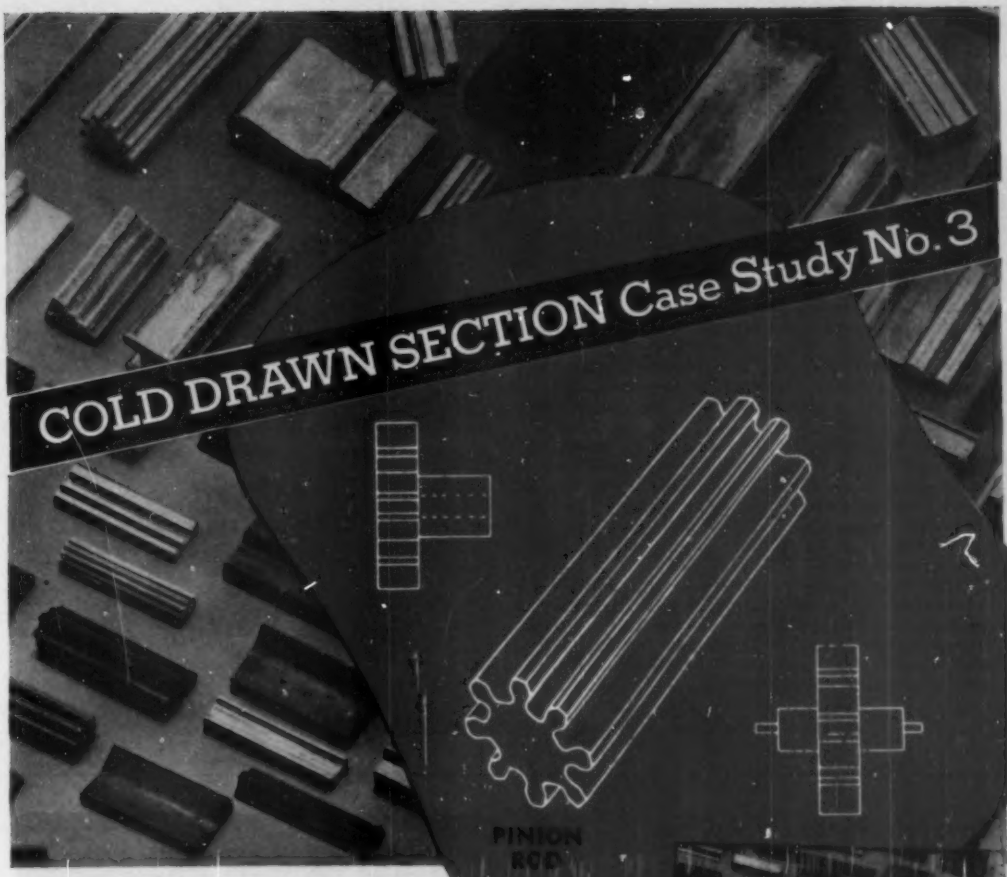
Tachometer Reads on Long Scale of Indicator

This new electric tachometer features a flush mounting indicator with a 250 deg scale. The scale length is 8.7 in. while the diameter of the case is 5½ in. The guaranteed accuracy is within 2 percent of full scale deflection. Although this accuracy is no better than that provided by indicators of the same size having 90 deg scales, the manufacturer claims that the 250 deg scales, which are more than twice as long, will facilitate reading the indicator more readily and with less chance of error within their guaranteed accuracy.

Standard scales are calibrated in RPM, but special scales are available to read feet per minute, gallons per minute, impressions per hour, or any other units of speed. The permanent magnet generator is furnished in a 12 pole design. The unit is available with base, flange, or SAE mounting and is intended for operation at speeds up to 10,000 RPM.

The Chicago Electric Tachometer Co., Madison, Ohio

CONTINUED ON PAGE 190



Pinions produced 3 to 5 times cheaper

Pinions made from RATHBONE PRECISION COLD DRAWN PINION ROD cost from *three* to *five times* less than cut pinions. In some cases the ratio is 10 to 1 in favor of RATHBONE PINION ROD. Reports from one of our many customers indicate that, in addition to an outstanding saving in cost, pinions made from RATHBONE COLD DRAWN STOCK, under *actual test*, give seven times the length of service of cut pinions.

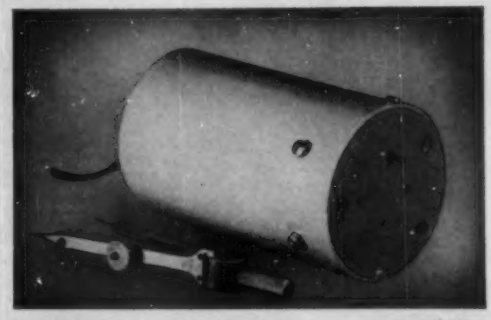
These are only some of the benefits because, in every case, cold drawn sections have a hard, smooth skin which is not removed by machining. Furthermore, dimensional accuracy is maintained. Cold drawn pinions can be depended on for longer life and less friction. They can be produced in a wide variety of materials to meet application requirements. Product improvement is assured by their use, and is such as to warrant your most careful investigation. Your inquiries are solicited. You incur no obligation in sending us your drawings for our recommendations.

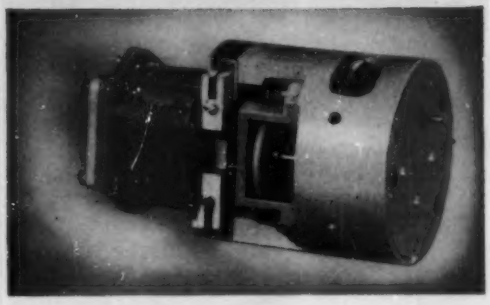
Full details concerning RATHBONE Cold Drawn Shapes will be found in a NEW 16-page technical bulletin available promptly on request. Ask for your copy TODAY.

COLD DRAWN SHAPES to your specifications—at big savings.

RATHBONE *Corporation, Palmer, Mass.*

12 Ounce Motor Gives DC Time Integral





The speed of this motor is stated as proportional within 0.5 percent to applied voltages between —15 and +15 volts. Angular shaft displacement over any given period, therefore, is proportional to the integral of applied voltage during that period.

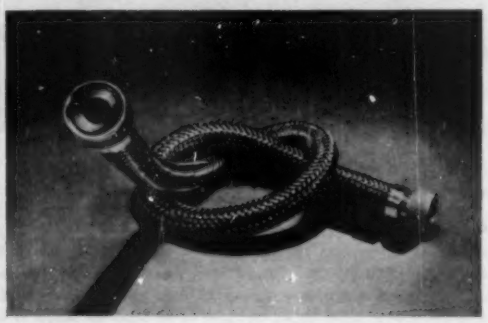
In the model illustrated, the armature is geared to a single output shaft at a ratio of 500 to 1. Also available is a model with armature geared to two output shafts, at 100 to 1 and 1000 to 1.

A torque to inertia ratio of 400,000 to 1 at 1 volt applied is claimed. Weight is 12 oz, with greatest overall dimension of 3¾ in. A unique feature of this motor is the claim that it will consistently start and run on the energy supplied by a photo-cell exposed to sunlight. Construction features include the use of jeweled bearings to maintain the above torque to inertia ratio.

This motor is designed for use in applications where the time rate of any process, operation, or movement can be made to control a voltage in exact proportion. If this voltage is then applied to the integrator motor, its output shaft will record by its angular displacement the extent the process or movement has progressed.

Specialties, Inc., Skunks Misery Rd., Syosset, L. I., N. Y.

Flexible Hose Offered In Stainless Steel



This new line of flexible stainless steel hose is offered for liquid and gas corrosion service. Flexible, the hose is designed for vibration and variplane motion conditions. Construction will vary to fit the amount of flexure necessary. Available in sizes from $\frac{1}{16}$ to 6 in. ID, in one or multiple ply construction, this product has wall thicknesses from 0.003 to 0.030 inch. Working pressures are allowed up to 2,000 psi. Standard or special fittings are attachable by silver brazing or welding.

Chicago Metal Hose Corp., 1304 So. Third Ave., Maywood, Ill.

Leaded Steel Machines at High Speed

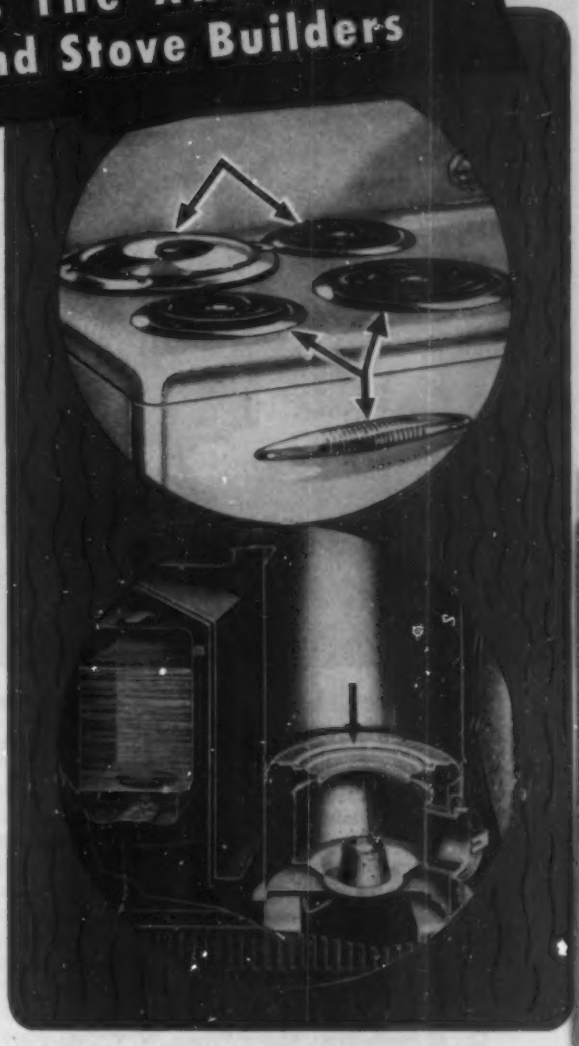
This steel is offered in response to a demand for faster machining screw stock steels. It is a cold finished open-hearth steel, not a Bessemer product, with lead added. It is rephosphorized and resulphurized, and has a carbon content of .08 to .13 percent. The intention is to replace Bessemer and plain resulphurized open hearth steels with this new cold finished product.

Extensive tests have been conducted by the manufacturer as to machining speed. In this respect, the function of the lead in this steel is to lessen the friction between chip and tool, and thus cut heat. The tests run are claimed to show important gains in cutting speed. The new steel is also stated to be superior to Bessemer Steels in ductility, carburizing qualities, freedom from surface defects, and in cross-section soundness. A surface cutting speed of 325 fpm has been set as standard for the new steel on maintained runs.

LaSalle Steel Co., P. O. Box 6800-A, Chicago 80, Ill.

CONTINUED ON PAGE 192

SHARON STAINLESS Provides the Answers For Range and Stove Builders



Many range builders are finding Sharon Stainless ideal for all trim, but especially that trim that rings the burners. Sharon Stainless remains bright and shiny, easy-to-clean year after year under constant usage. Burner trim rings of Sharon Stainless resist discoloration and warp regardless of heat generated by range. These factors add up to *higher quality and stronger sales ammunition.*

●

For baffles, burner bowls and combustion chambers, stove and heater builders have added years of life to their products by switching to Sharon Quality Stainless. Sharon Stainless is especially heat resistant. It will not deteriorate under the hottest temperatures. And what's more, Sharon Stainless withstands rapid and extreme changes of temperature—a perfect metal for manufacturers who must contend with heat and cold.

●

Why not examine your product. Think of Stainless, and when you do—think of Sharon, pioneer and prime producer of fine steels for almost 50 years. If you would like engineering help or fabrication information, let us know. No obligation, whatsoever.

SHARON STEEL CORPORATION *Sharon, Pennsylvania*

PRODUCTS OF SHARON STEEL CORPORATION AND SUBSIDIARIES: THE NILES ROLLING MILL COMPANY, NILES, OHIO; DETROIT TUBE AND STEEL DIVISION, DETROIT, MICHIGAN; BRAINARD STEEL COMPANY, WARREN, OHIO; SHARONSTEEL PRODUCTS COMPANY, DETROIT, MICHIGAN, AND FARRELL, PENNA.; CARPENTERTOWN COAL & COKE CO., MT. PLEASANT, PENNA.; FAIRMONT COKE WORKS, FAIRMONT, W. VA.; MORGANTOWN COKE WORKS, MORGANTOWN, W. VA.; JOANNE COAL COMPANY, RACHEL, W. VA. Hot and Cold Rolled Stainless Strip Steel—Alloy Strip Steel—High Carbon Strip Steel—Galvanite Special Coated Products—Cooperage Hoop—Electrical Steel Sheets—Hot Rolled Annealed and Descaled Sheets—Galvanized Sheets—Enameling Grade Steel—Welded Tubing—Galvanized and Fabricated Steel Strip—Steel Strapping, Tools and Accessories.

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because of solid rectangular contacts

The greater number of solid rectangular contacts gives Ward Leonard multi-step rheostats finer control with smoother contact arm operation—and with all the advantages of the Vitrohm construction.

The solid metal contacts, connected to the resistance element by a patented Ward Leonard method and embedded in vitreous enamel—assures a mechanically and electrically perfect joint for long and constant service.

Write for Rheostat Catalog. Ward Leonard Electric Co., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC COMPANY
Result-Engineered Controls
RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

Split Thrust Washers Install Easily

Designed to facilitate repair, these split thrust washers allow replacement without dismantling machinery. The split washer is slipped over the shaft and locked in place with the safety key. This item is manufactured especially for heavy construction machinery, material moving equipment, power house and pump installations, plant machinery, and oil field equipment.

These thrust washers are made of a special bronze with high purity copper, tin, and lead, and containing a maximum of .2 percent impurities. They can be supplied in any practicable size, made to order on specification.

Saginaw Bearing Co., 821 S. Water St., Saginaw, Mich.

Compactible Stainless Steel Powders

These new stainless steel powder types feature a high rate of compactibility which allows the pressing of more intricate shapes than previously possible with stainless steel powders.

The company claims a green strength—that is, the strength of the pressed compacts before sintering—of up to 15 times that of ordinary stainless steel powders. The chemical analysis of the new powders corresponds to that of standard chrome and chrome-nickel steels, and parts prepared by pressing and sintering the powders exhibit the high mechanical strength and corrosion resistance characteristic of these compositions. The new powdered stainless steel meets all requirements of the powder processing industry.

American Electro Metal Corp., 320 Yonkers Ave., Yonkers 2, N. Y.

Composition Lining Resists Corrosion

This carbon-compound lining material is offered for use with steel and wood tanks to resist corrosion from most equipment eating substances—acid, alkali, salt and solvent solutions—up to 250 F. The manufacturer should be consulted for full information on corrosion resistance.

Wood surfaces should be dried by kerosene torch or sunlight before application of the basic coat. The coating, applied with a trowel, will harden in 24 hours at normal temperature. If a slick surface is desired, a second coat of finishing material, also furnished

by the manufacturer, can be used. Both materials are prepared by mixing powders and solvents at the job. Most old tanks will need only the bottom and the lower 18 in. of the inside walls finished, but if the entire tank is lined it will be necessary to coat the outside to prevent the staves from drying out and causing cracks in the lining due to shrinkage. A vinyl base point will be satisfactory.

Steel tanks must be cleaned and wire-brushed or sandblasted before treatment. Two coats of a special primer are then applied. These will normally dry within 24 hours, although infra-red lamps may be required in cold weather. With this preparation, the surface is then lined with the basic protective compound, which is troweled on, as in the case of the wood tank. The coating is made about $\frac{1}{16}$ in. thick. While the coating is still soft, a layer of fiber-glass cloth is pressed on top and allowed to harden in place. Another $\frac{1}{16}$ in. coating of the basic compound is then applied over the fiber-glass. As before, if a smooth finish is desired, one or two coats of a special finishing compound can be applied. The final coat of basic compound or finish should dry for from 24 to 48 hours before the tank is put into operation.

Carboline Co., 7603 Forsyth Blvd., St. Louis 5, Mo.

Terminals Feature Thermoplastic Resin

These multi-electrode hermetically sealed terminals are designed to meet Army-Navy seal component specifications. Thermal and electrical insulation characteristics are obtained by the use of a special trifluorochloroethylene thermoplastic resin in the terminal heads.

Operating potentials are 3,000 v at sea level to 1,500 v at 50,000 ft. Current rating is 15 amp rms, while temperature range is from +200 C to —195.8 C. Insulating resistance is 1,000,000, meg-ohms and water absorption is 0.00. The terminals are available with 3 to 9 leads of standard or special design.

Molding Corp. of America, 50 Weybosset St., Providence, R. I.

Electrical Reset Register

Called the Model 1238, the device permits a choice of three types of register actuation and, for added convenience, can be reset automatically in approximately one second with a switch on the front panel or from re-

because exclusive "component-matching" prevents failures

The sure way to avoid trouble due to resistor failure is to use the resistor with the *matched* components.

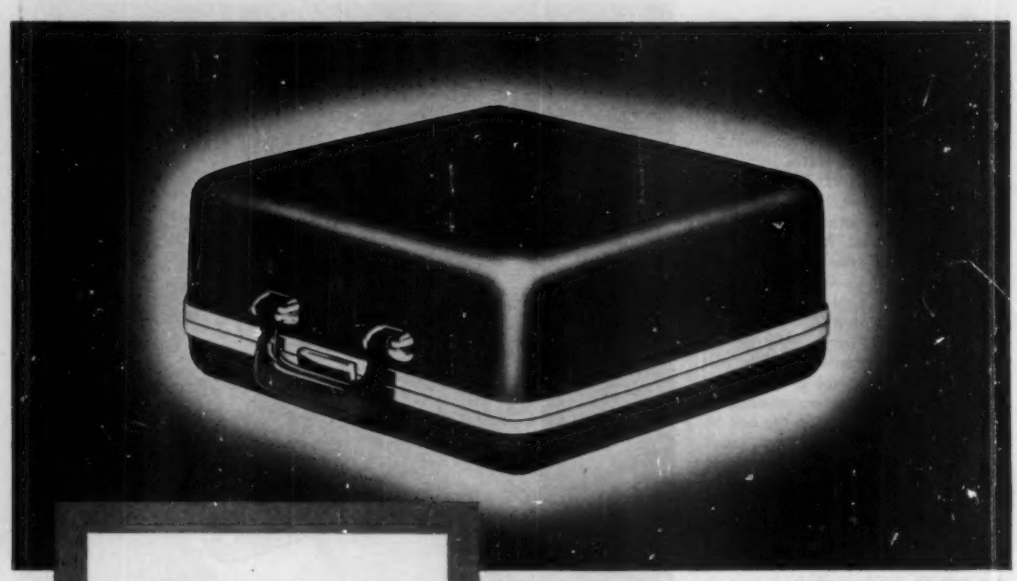
Ward Leonard alone *makes*—not just assembles—all the components of a resistor. (Wire is drawn to Ward Leonard specifications.) This means that all components are *balanced* in respect to thermal coefficient of expansion and other factors affecting service life. No loosening, no failure—because all parts react the same to their "environment."

Write for bulletin on Vitrohm Resistors, WARD LEONARD ELECTRIC CO., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC COMPANY

Result-Engineered Controls

RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES



Typewriter case of Royalite made for the Smith-Corona Portable

SMITH-CORONA SELECTS *Royalite* FUNCTIONAL, DECORATIVE THERMOPLASTIC

L. C. Smith and Corona Typewriters, Inc., are just one of the many leading manufacturers who selected strong, beautiful Royalite for use with their products.

This remarkable thermoplastic combines the best qualities of synthetic rubber and plastic. It can be formed into simple or complex shapes; sawed, sheared, drilled, punched, sanded, sewed, cemented, polished. It can be produced in almost any color, in smooth or grained finish.

Royalite is lightweight, non-corrosive, with a very high impact strength. It is an excellent heat or cold insulator, with good dielectric qualities. It comes in sheets any thickness from .0312" to .500", in any color, solid throughout its thickness.

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C. K. Castaing Studio, 17862 S. Huntington Beach Blvd., Huntington Beach
National Hollywood, 1475 El Mirador Drive, Pasadena 2
Peninsula Plastics Co., 2901 El Camino Real, Redwood City

COLORADO
Pikes Peak Plastic, 5 W. Cucharras St., Colorado Springs
Plasticraft Co., 2806 N. Speer Blvd., Denver

CONNECTICUT
Colt's Mfg., Hartford 15

GEORGIA
Gladwin Plastics, 542 Courtland St. N.E., Atlanta

ILLINOIS
Arrem Plastic, 1539 N. Throop St., Chicago 22
Croname Inc., 3701 Ravenswood Ave., Chicago 13
G. Felsenthal & Sons, 4100-4118 W. Grand Ave., Chicago 51
Lamicoid Fabricators Inc., 4545 W. Cortland St., Chicago 39
Neo Products Co., 2534 So. Kedzie, Chicago 23
Northwestern Plastics Inc., 2535 W. Washington Blvd., Chicago 12
Precision Plastic Products Inc., 628 W. Lake St., Chicago 6

INDIANA
General Plastics Corp., 1400 N. Washington, Marion
Plastic Mfg. & Designer Corp., 422 W. 9th St., Indianapolis 6

MARYLAND
Fawn Plastics Co., 2902 Hamilton Ave., Baltimore 14

MASSACHUSETTS
Koehler Mfg. Co. Marlboro

MICHIGAN
Cadillac Plastic Co., 651 W. Baltimore, Detroit 2
Detroit Macoid Corp., 12340 Cloverdale Ave., Detroit 4
Imperial Industries, 4435 Walker Ave., Wayne
Klise Mfg. Co., 50 Cottage Grove S.W., Grand Rapids 2
Woodall Industries Inc., 7565 E. McNichols Rd., Detroit 34

MINNESOTA
Plastics, Inc., Chestnut & Ryan Sts., St. Paul 2

MISSOURI
Plastic Design Co., 322 Clark Avenue, St. Louis 2
Regal Plastics Co., 710 Main St., Kansas City

NEW JERSEY
Thermacote Co., 320 Jefferson St., Newark 5
Van Beek Industries, 23 Park St., Orange
Wood's Plastic Inc., 410 Frelinghuysen Ave., Newark 5

NEW YORK
Bassons Molded Products, 1424 W. Farms Road, New York 60
Blue River Plastics, 320 Canal St., New York 13
Curbell Inc., 1700 Elmwood Ave., Buffalo 7
Dual Fabricators Corp., 808 Driggs Ave., Brooklyn 11
Dura Plastics Inc., 1 W. 34th St., New York 1
Steiner Plastics Mfg. Co., 47-36 33rd St., Long Island City 1

OHIO
Fabri-Form Co., Box 36, Cambridge

OKLAHOMA
Magic Circle, 6224 East Admiral Place, Tulsa 15

PENNSYLVANIA
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Halsen Mfg. Co., 5919 Webster St., Philadelphia

TEXAS
Glow-Lite Plastic Arts Co., 715 So. Comal St., San Antonio 5
Plastic Engineering Co., 2101 69th St., Houston 11
Plastic Products of Texas, 3319 Love Field Dr., Dallas

WASHINGTON
K. B. Plastics, Inc., 1817 So. 1st St., Yakima

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Midland Plastics Inc., 227 N. Water St., Milwaukee 2

The United States Rubber Company at 3638 North Pulaski Road, Chicago, Illinois, has complete Engineering, Designing, and Styling Departments to assist fabricators on the technique to employ, and in the art of fabricating, most efficiently with ROYALITE.

motely located contacts. Accurate counting from 1 to 999,999 at up to 12 counts per second is possible. Reliable register actuation is obtained with as little as 10 Ma. at 50v or with external contacts utilizing the build-in dc supply. The unit operates on 105-125 v, 50-60 cycle alternating current and draws 5 watts during normal operation, 30 watts maximum during resetting. A major advantage pointed out by the manufacturer is the ability to interlock this reset mechanism with other controls to minimize possibility of error.

Atomic Instrument Co., 160 Charles St., Boston, Mass.

Electric Counter Mounts Flush

A small electric counter for panel mounting and for built in applications has been developed. The unit is permanently enclosed in a metal case with plastic window. Non-resetable, it counts to 99,999 before repeating, and is tested by the manufacturer at 600 counts per min. The overall dimensions are 2¾ by 1¾ by 2¼ in., and electrical specifications allow for use on 6, 24, 30, 115, and 230 volts ac and on 6, 24, 30 and 115 volts dc.

Production Instrument Co., 702-10 W. Jackson Blvd., Chicago 6, Ill.

Switch Operates At Two Pressures

This pressure switch is designed to operate at any two predetermined pressures. A diaphram sensing element operates two SPDT snap-action switching elements at any two independent pressures. Six classes of switches are offered to provide adjustable ranges

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ACE MOLDED HARD RUBBER

HERE'S an "idea kit" guaranteed to stir your imagination and give you a hat full of hints for improving your products with strong, durable, corrosion-resistant, and electrically excellent Ace Hard Rubber. Yes, a few of the newer Ace plastics are included, too.

The kit shows how every property of hard rubber can be used to best advantage. It demonstrates cost-saving hints in molding, and shows a wide variety of design techniques, including inserts, shrink fits, machined parts, extruded parts, parts that are blown like glass bottles, etc.

Our sales engineer in your territory will be happy to spread these ideas out on your desk at the drop of a postcard. If you have a particular problem in mind, mention it. Chances are we've done something similar in our 98 years and can bring a sample of *that* along, too. *Write today.*

Have you a copy of the Ace Hard Rubber & Plastics Handbook? If not, just ask.

ACE AMERICAN HARD RUBBER COMPANY

HARD RUBBER and PLASTICS

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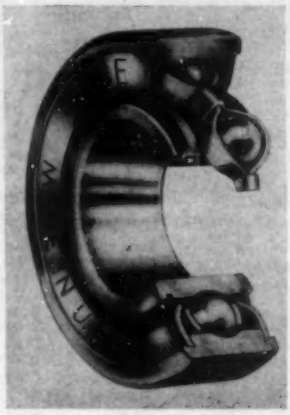
from 2 in. of water to 100 psi, with proof pressures up to 120 psi. The mechanism is designed for use as a warning signal, for maintaining constant pressure between two limits, or as a sequence control. Housing dimensions are 3 in. diameter by 4½ in., overall. The weight is 12 oz. Pressure connections have ¼ in. internal thread, while electrical connection is through ½ in. conduit connector.

Meletron Corp., 950 N. Highland Ave., Los Angeles 38, Cal.

Composition Sealed Bearings

Called "composition sealed", these ball bearings use an oil resistant rubber coated fabric in contact with a specially formed metal shield. The new design is claimed to effectively

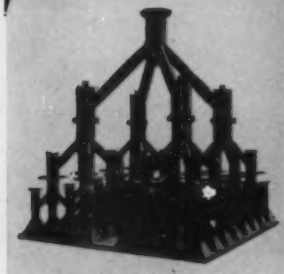


retain lubricant and exclude foreign material, performance advantages that are necessary requirements for many bearing applications. The new composition seal has been applied to series 1600 and 3000 bearings. Series 1600 are "ground all over" precision annular bearings while Series 3000 are inexpensive unground radials of the same "precision type", as illustrated.

Nice Ball Bearing Co., Philadelphia, Pa.

Electronic Relay System

This new electronic relay system operates from a 115 v, 50-60 cycle line and uses no filament to draw standby power with the relay circuit energized. Operation is initiated by the contact of a drop wire, contact-making instrument, or any conductive medium between the two contacts having a resistance as high as one million ohms. Maximum current flow through the

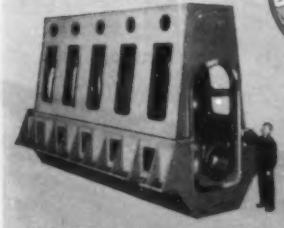


One of Several Parts of a Catalytic Cracking Plant Produced for the Petroleum Industry.

Pressure Vessels for the Chemical and Allied Industries.

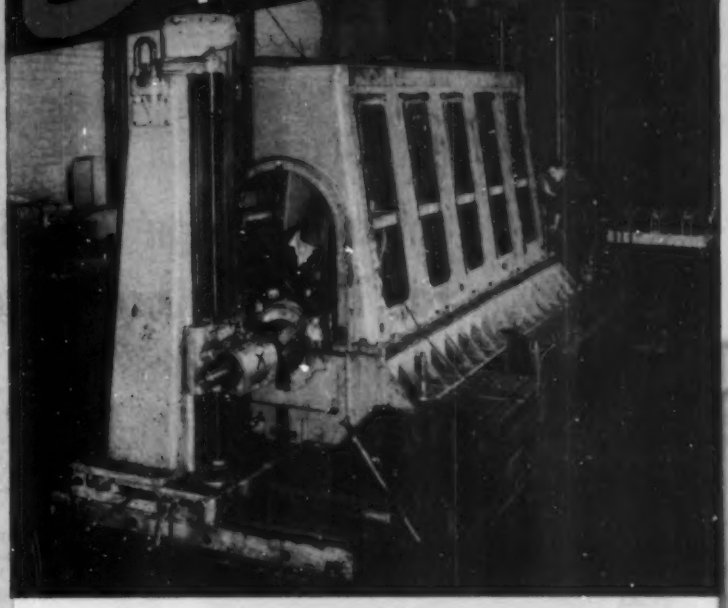
Heavy Press and Machine Frames and Bases for the Machine Tool Industry.

Diesel Engine Crank Cases and Frames for the Marine and Electro-Motive Field.

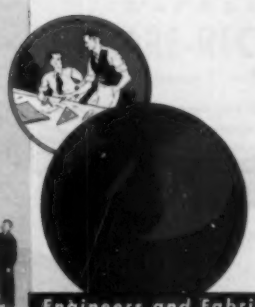


Crank Cases, Frames, and other Parts for Manufacturers of Marine Steam Engines of Uniflow or Multiple Expansion Type.

Steel-Weld FABRICATION



Boring Crank Shaft Bearings of a large Steel-Weld Fabricated Marine Steam Engine Crank Case and Frame in the Machine Shop of the Steel-Weld Division of The R. C. Mahon Company.



Thousands of Steel-Weld Fabricated parts and major assemblies are produced each year by the Mahon organization for manufacturers of heavy machinery and equipment throughout the country ... some of these assemblies run into hundreds of tons and involve many problems which demand skillful designing and advanced technique in fabricating procedure. Steel-Weld Fabrication will save you money too ... and, you will find in the Mahon Company an unusual source for welded steel in any form for any purpose ... a source with complete, modern fabricating and machining facilities, backed by a staff of competent design engineers and craftsmen from whom you may expect a smoother, finer appearing job, embodying every advantage of Steel-Weld Fabrication.

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Valuable Design Flexibility Even For The Less Complicated Parts

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ZINC and ALUMINUM DIE CASTINGS

The three segments of a circle here illustrated show bosses, beads, smooth edges, and true radii so necessary in washing machine service. No other process can provide these features so easily or economically.

You may be able to reduce the weight of your parts, add eye appeal, strength, and economy by adopting Madison-Kipp die castings.

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initiating resistance is in the order of microamperes. This extreme sensitivity allows operation of the load relay whose silver contacts and high contact pressure allow for control with load currents as high as 4 amps, dependent upon voltage and load inductance. This makes possible the use of ordinary electrical meters as primary activating sources in many control and alarm applications. The load relay contacts are arranged to permit a choice of either opening or closing a circuit, or simultaneously to open one circuit and close another. A "hold" circuit is incorporated for optional use (internal jumper) so that the load relay may remain energized from a momentary initiating medium or contact. When the hold circuit is in use, a "reset" switch on cover will manually restore the circuit to another operation cycle.

Servo-Tek Products Co., 4 Godwin Ave., Paterson 1, N. J.

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Manufacturer's tests show that this new carbon brush shunt connection will not pull or jar loose from the brush, and will maintain its original millivolt drop. It is also designed to avoid oxidation and to remain unaffected by extreme operating temperatures.

United States Graphite Co., Saginaw, Michigan

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"Beware of little expenses! A small leak will sink a great ship."

—Ben Franklin's Almanac, 1757

One penny dropped maketh not much noise but thousands of pennies dropped over the year maketh a big bang before ye annual stockholders' meeting.

—Acme Steel's Notebook, 1950

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Here at Acme Steel Company, we have shown more than 50,000 customers how to cut costs, save time, labor and materials with Acme stitching machines and wire, Acme flat steel strapping, and other Acme Steel products. In 9 out of 10 cases, Acme sales engineers are able to start you on the road to thrifty benefits.

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Saves 2 minutes' assembly time, per ladder, with wire stitching

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MEETINGS

May 5-6

AMERICAN PHYSICAL SOCIETY—National Meeting and Midwestern Conference on Fluid Dynamics, University of Illinois, Urbana, Ill.

May 9-11

CONFERENCE ON IMPROVED QUALITY ELECTRONIC COMPONENTS. Sponsored by AIEE and IRE. 1317 F St., N.W. Washington, D. C.

May 25-27

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS — Spring Meeting, Hotel Statler, Cleveland, Ohio.

May 29-June 9

CANADIAN INTERNATIONAL TRADE FAIR—Exhibition Grounds, Toronto, Canada.

June 4-9

SOCIETY OF AUTOMOTIVE ENGINEERS—Summer Meeting, French Lick Springs Hotel, French Lick, Ind.

June 11-15

AMERICAN ELECTROPLATERS' SOCIETY—37th Annual Convention, Hotel Statler, Boston, Mass.

June 12-16

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Summer and Pacific General Meeting, Huntington Hotel, Pasadena, Calif.

June 19-23

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Semi-Annual Meeting, Statler Hotel, St. Louis, Mo.

June 22-24

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Applied Mechanics Division Conference, Purdue University, Lafayette, Ind.

June 26-30

AMERICAN SOCIETY FOR TESTING MATERIALS—53rd Annual Meeting and Exhibit. Chalfonte-Haddon Hall, Atlantic City, N. J.

August 7-19

INTERNATIONAL TRADE FAIR — Coliseum Arena and Navy Pier, Chicago, Ill.

August 14-16

SOCIETY OF AUTOMOTIVE ENGINEERS—West Coast Meeting, Biltmore Hotel, Los Angeles, Calif.

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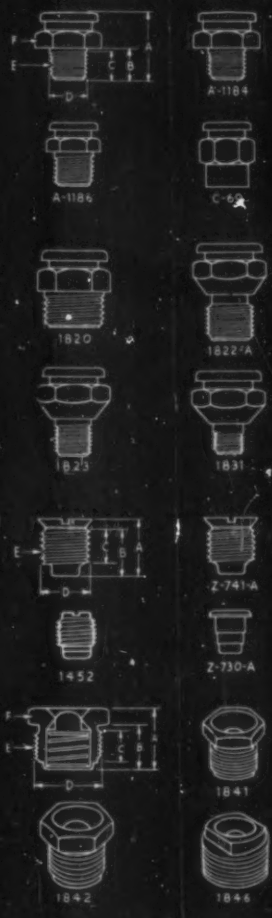

STANDARD BUTTON HEAD FITTINGS

Part No.	DIMENSIONS A	B	C	D	E	F*
C-69	39/64"	13/32"	9/32"	39/64"	1/8" P.T. Female	5/16"
A-1184	1/2"	11/32"	1/4"	13/32"	1/8" P.T.	5/16"
A-1186	39/64"	27/64"	15/64"	25/64"	1/8" P.T.	5/16"
A-1188	61/64"	31/64"	27/64"	43/64"	1/8" P.T.	5/16"
A-1190	1 1/64"	35/64"	31/64"	27/32"	1/8" P.T.	5/16"
1396	1"	1/2"	13/32"	43/64"	1/8" P.T.	5/16"
1401	59/64"	37/64"	1/2"	59/64"	1/8" P.T.	5/16"

*Wrench Size.

GIANT BUTTON HEAD FITTINGS

Part No.	DIMENSIONS A	B	C	D	E	F*
1820	1 1/16"	1/2"	13/32"	27/32"	1/8" P.T.	5/16"
1821	1 5/16"	9/16"	7/16"	1/2"	1/4"-18 Thd.	1/2"
1822-A	1 5/16"	9/16"	39/64"	43/64"	1/8" Spec. P.T.	1/2"
1823	1 1/4"	1/2"	1/2"	39/64"	1/4" P.T.	1/2"
1825	2"	41/64"	11/32"	43/64"	1/8" P.T.	5/16"
1831	1 5/32"	5/8"	9/32"	13/32"	1/8" P.T.	5/16"
**1871-A	1 5/16"	9/16"	39/64"	43/64"	1/8" P.T.	5/16"
**1872-A	1 1/4"	1/2"	1/2"	39/64"	1/4" P.T.	1/2"

*Wrench Size. **1871-A and 1872-A have special construction to withstand extremely high pressures. Recommended for use on lubricated valves.

FLUSH TYPE FITTINGS

Model No.	A	B	C	D	E
†Z-730-A	7/16"	3/8"	.....	5/16"	.....
Z-741-A	9/16"	15/32"	5/16"	39/64"	1/8" P.T.
1452	1/2"	29/64"	25/64"	13/32"	1/8" P.T.
†1814	27/64"	9/32"	.....	5/16"	.....
1815	33/64"	5/16"	9/32"	13/32"	1/8" P.T.
†1817	11/32"	19/64"	.....	5/16"	.....
†1855	11/32"	19/64"	.....	1/4"	.....

†Drive Fittings.

GIANT FLUSH TYPE FITTINGS

Model No.	A	B	C	D	E	F*
1840	49/64"	29/64"	31/64"	3/4"	3/8"-11 Thread	3/4"
1841	49/64"	29/64"	31/64"	43/64"	1/8" P.T.	5/8"
1842	55/64"	29/64"	1/2"	27/32"	1/4" P.T.	5/8"
1843	7/8"	29/64"	1/2"	1 5/64"	1/4" P.T.	1 1/16"
1844	7/8"	29/64"	31/64"	1 5/64"	1" P.T.	1 1/16"
*1846	49/64"	19/32"	19/32"	1 5/64"	3/8" P.T.	11/16"
**1847	55/64"	29/64"	1/2"	27/32"	1/4" P.T.	11/16"

*Wrench Size. **Flush Fit No Hex.

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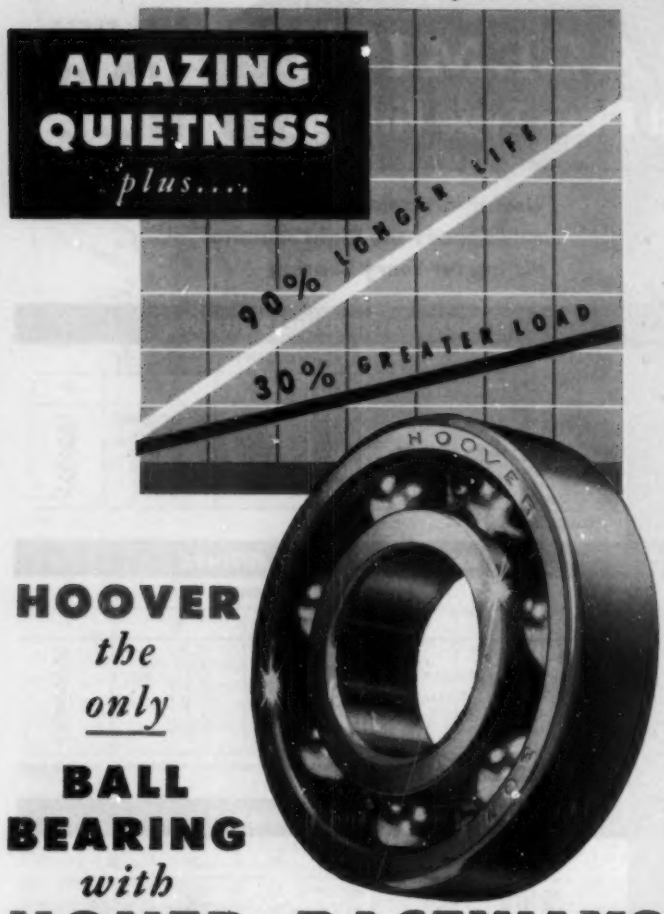

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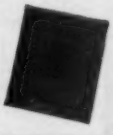

THE ARISTOCRAT

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Ann Arbor, Michigan

OUR READERS SAY

There's No Place Like Home

SHOE SHINE BOY
WIPE YOUR TEARS

(Special to the Nassau Daily Review-Star)
NEW YORK, April 5—

Shoe shine artists may be facing a grim future, according to PRODUCT ENGINEERING, a McGraw-Hill publication. Science has developed a process which combines leather and rubber to produce a highly durable material.

When soaked overnight in a rubber solution and then vulcanized, low-grade leather absorbs only half as much water as untreated hides and is twice as resistant to abrasion—bad news for the shoe-shine boys if footgear is made from the new material.

Ed—We didn't think this could happen, but . . . you never know!

Safety Factors for Springs

To the Editor:

I have examined with considerable interest the Reference Book Sheet on "Maximum Design Load vs. Temperature for Springs" by O. G. Meyers in your December 1949 issue. It appears to me that the author has omitted the following important factors governing spring design:

(1) The author does not take into consideration values of safety factors depending on nature of duty for which springs are required. These factors should range from two to five.

(2) Severe stress drops affected by elevated temperatures are not in accordance with recent material tests. There should not be a stress drop in material heated up to 200 F. Therefore, the allowable stress drop from 180,000 psi to 70,000 psi is questionable.

(3) It is not clear to what spring material sizes the values of allowable nominal stress correspond. With the same factor of structural safety, say three, the actual allowable stress in 0.014 in. music wire is 325,000/3 = 108,330 psi. For a $\frac{3}{32}$-in. wire, the stress will then be 236,000/3 = 78,670 psi, a 37 percent deviation.

(4) It would be helpful to have data for the Modulus of Elasticity as affected by elevated temperatures.

(5) The formula for allowable spring force used in the chart neglects stress correction factors. The actual stress is higher. The following examples demonstrate the questionable

* How to raise gears to live and work together

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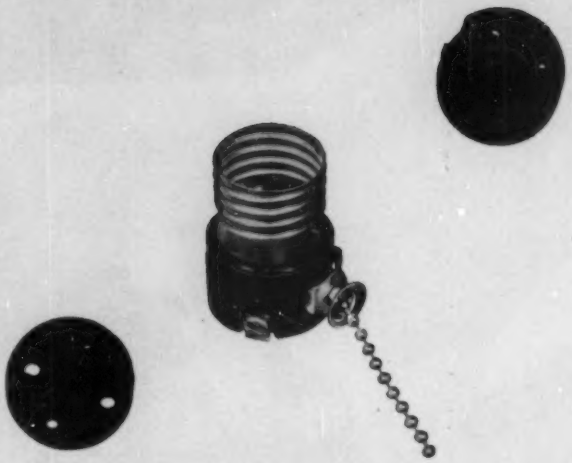
SKJ Electric designs for low-cost molding



The two plastic components of the SKJ lampholder are molded on the Stokes 741 completely automatic molding press. This high-speed, high production Stokes press, installed at SKJ Electrical Products, Inc., New York City, operates on an uninterrupted production schedule.

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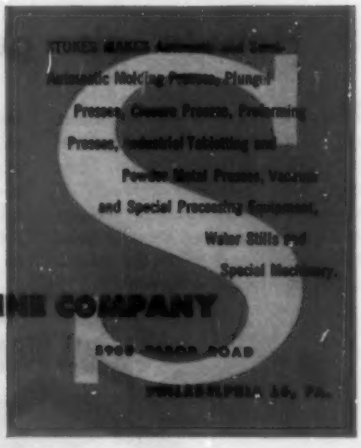

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results obtained when using values of allowable stress recommended by Mr. Meyers:

Example 1. A compression spring suitable for use in a steam cylinder relief valve has following specifications: Outside diameter, D, of 0.283-in. (d) music wire spring is 1½ in.; maximum load, P, exerted on the spring is 300 lb; allowable stress

$$S = \frac{2.55\,(D-d)\,\phi P}{d^3}$$

Selecting ratio

$$\frac{D}{d} = C = \frac{1.5}{0.283} = 5.3$$

and stress correction factor

$$\phi = \frac{C-1.25}{C-2} + \frac{0.615}{C-1} = 1.47$$

then

$S = 60{,}000$ psi.

Ultimate strength of 0.283-in. wire in torsion is 170,000 psi. Factor of structural safety K is 170,000/60,000 = 2.8. From the "5" curve in the chart, we obtain $K = 170{,}000/140{,}000$ or 1.2.

Example 2. A compression spring for an automobile engine has following values specified: Outside diameter D of the 0.331-in. chrome-vanadium steel wire spring is 2¼ in.; maximum pressure P developed by the spring is 260 lb. The spring coils are heated to 300 F. Using valves $C = 2.25/0.331 = 6.8$ and $\phi = 1.26$, the allowable stress, S, is 44,300 pounds per square inch.

Ultimate strength of 0.331 in wire in torsion is 223,000 psi. Thus safety factor K is 223,000/44,300 = 5, which corresponds to many millions of load applications. According to curve "3" in the chart, K is 223,000/64,500 = 3.45.—VICTOR TATARINOV, *Pilsen, Czechoslovakia*

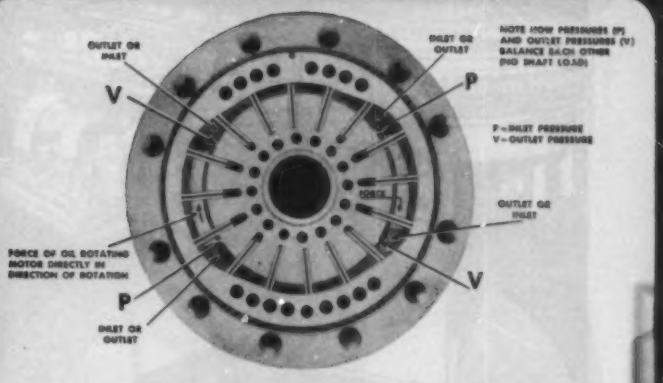
Ed—Author Meyers' answers to Mr. Tatarinov's comments follow:

(1) "The data published were collected from actual tests. The safety factor mentioned by Mr. Tatarinov seems rather high. The Hunter Company feels that the safety factor of 1.5 is adequate. Perhaps these high safety factors (3 to 5) are used because very little fatigue data (other than Hunter's) are available and these factors are the method of making allowance for fatigue. In applying Hunter's design procedure, fatigue is taken into account and thus the smaller safety factor is permissible.

(2) "The curves used represent points of no relaxation in stress. Each curve is derived from a family of curves as shown. Referring to the graph and, in particular, to the curve at 100,000 lb stress, it will be noted that this stress is maintained until a

Save Money! Save Space!

Dudco VANE-TYPE MOTORS



Dudco Vane-Type Motors operate by direct force of the fluid against the vanes. The fluid enters through ports which are diametrically opposed, to balance shaft loads, and discharges in the same manner. Notes included with the above figure relate to fluid motor construction. Pump operation is similar, with the dual vanes bearing radially outward with positive forces which, while adequate for pressure sealing, are balanced hydraulically to eliminate undesirable wear producing thrust against the ring.

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- Smaller size for same of application
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- Trucks (Hose reeling, conveyors).
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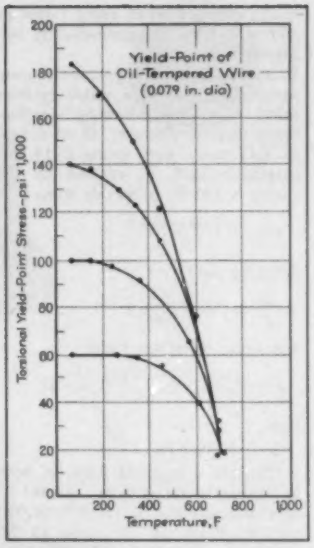


temperature of 150 F is reached. It then drops off. Thus, if the material were at 400 F, a relaxation would take place that would be equivalent to approximately 10,000 psi. However, if no relaxation is permitted, then the stress for design should be that indicated in the original data sheet.

(3) "The Hunter tests were conducted on $\frac{1}{16}$- to $\frac{1}{8}$-in. wire. These data can be projected to other wire sizes.

(4) "I believe your best reference for Modulus of Elasticity data will be found in the book on "Strength of Materials" by Timoschenko.

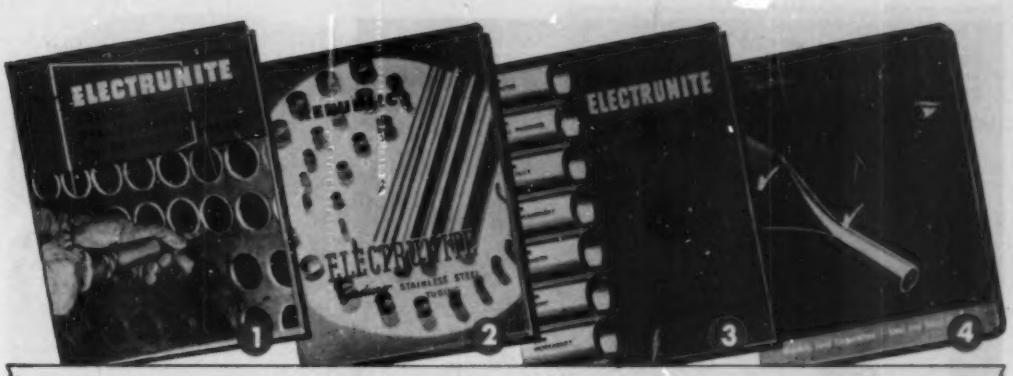
(5) "The formula used on the data sheet is the general form derived from basic formulas of a bar subjected to torsional forces. It should have a factor in the numerator that is called the stress concentration factor. Its usual designation is *R* and is referred to as the Wahl factor."

Points Well Taken

To the Editor:

I read with interest your February spread on "Operating Principles of Various Temperature Measuring Devices". I hope you won't mind my pointing out one generalization about resistance thermometers that could be misleading to a reader to whom the subject matter of your article is new.

You make the statement that the "necessarily large size of the resistance element is often a disadvantage". Then you say, "vibration and shock damage resistance thermometers". I believe you will be interested in our Stikon thermometer elements, Types



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MARMAN UNIVERSAL CLAMPS CONNECT FLEXIBLE DRAINAGE TUBE TO STAINLESS STEEL OUTLET. CLAMP ESPECIALLY RECOMMENDED FOR INSTALLATIONS WHERE HEAVY VIBRATION, IRREGULAR SHAPE AND CORROSION ARE FACTORS.
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MARMAN T-BOLT CLAMP USED IN CONJUNCTION WITH HARNESS CLIP AND BRACKET PROVIDES EFFICIENT MEANS TO ATTACH ELECTRICAL AND HYDRAULIC LINES TO LANDING GEAR STRUT. THIS ASSEMBLY PROVIDES HIGH SECURITY AGAINST VIBRATION WITH MINIMUM COMPLEXITY.
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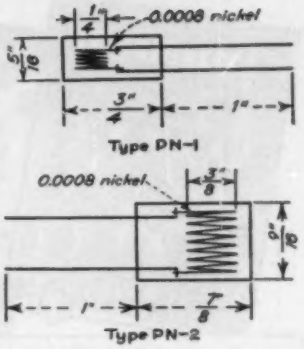


PN-1 and PN-2, (see cut), that completely avoid the limitations of your generalized statements. These are probably the lightest weight resistance thermometers ever marketed. Their resistance to vibration and shock damage is such that they have been used successfully for measuring temperatures on airplane propellers running at full speed. At 70 F, the PN-1 has a resistance of 50 ohms; the PN-2, 200 ohms. Both contain #30 tinned wire.

I imagine other resistance thermometer manufacturers would also take exception to your characterization of this member of the thermometer family. For example, the Foxboro Company manufactures resistance thermometers for measurement of surface temperatures on revolving rolls, the sensitive element being remarkably free from the limitations usually associated with resistance bulbs. This company also manufactures resistance bulb thermometers that possess remarkable characteristics as compared with the conventional bulb.

—ARTHUR C. RUGE
Ruge-deForest Inc

Ed—Dr. Ruge's points are well taken. We welcome comments of this nature.

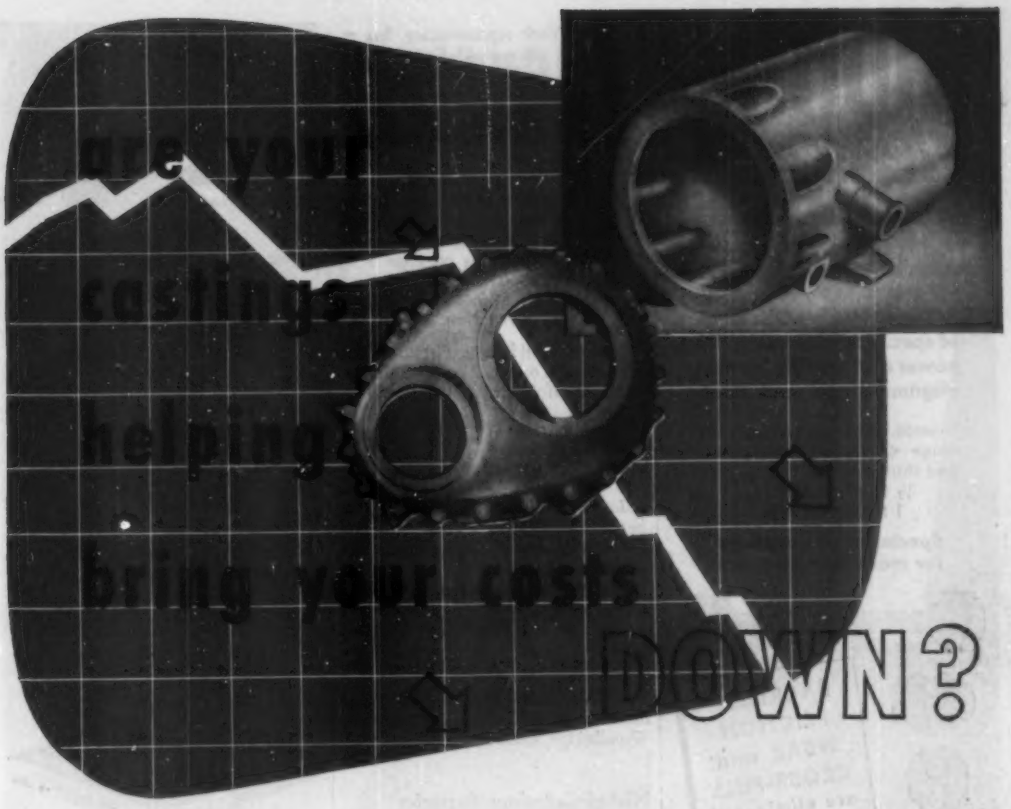
Where Can I Get It

Elusive Representative

To the Editor:

Kindly send us the name of the New York representative for Autronic Developments, Limited of Gloucester, England, makers of the magnetic clutch mentioned on page 158 of your February issue. I have written to the New York address shown but my letter was returned. —N. HERMAN
E. P. Lawson Co., Inc.

Ed—After cabling the parent office in England, we find that Mr. B. S. Bury,



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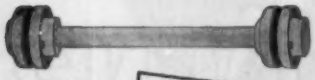

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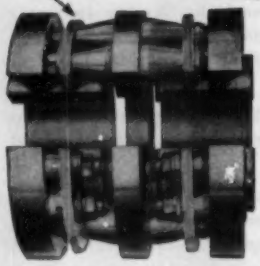

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the New York representative, has relocated his office at 47 East 64th St., New York 21, N. Y.

Synthetic Rubber Polymer

To the Editor:

Kindly send us additional information on the new Arctic Weather Synthetic Rubber Polymer listed under Nonmetallic Materials on Page 3 of the January 1950 issue of PRODUCT ENGINEERING.—MADDEN T. WORKS
Cameron Iron Works, Inc.

Ed—You should write Firestone Tire & Rubber Co., at Akron, Ohio for complete information.

Photo Copier

To the Editor:

In your February issue, page 210, in the "Our Readers Say" columns, you mention the new photographic copying device, Contoura.

May we please have the manufacturer's name and address so that we can obtain complete details regarding this product? —J. MAROSI
Hydraulic Brake Co.

Ed—This compact device is being marketed by F. G. Ludwig Associates, Woodbridge, Connecticut.

Nickel-Cadmium Batteries

To the Editor:

After reading the article on storage batteries in your February issue, I became particularly interested in the nickel-cadmium type, the idea being to install one in my car. What companies manufacture this type battery?
—HENRY LULLI
Long Island City, N. Y.

Ed—Mr. Carl Berg of The Nickel-Cadmium Company, Easthampton, Massachusetts; or Mr. Sven Bergstrom of Nife, Incorporated, Room 1002, 165 Broadway, New York City can supply all the details.

Copper Paste

To the Editor:

We have a production problem that requires brazing of a copper paste. The short item in the Highlights section of your February issue mentions such a paste. May we have the name of the supplier? —H. B. KOTHE
Knapp-Monarch Co.

Ed—Get in touch with the Metals Refining Company, 1717 Summer St., Hammond, Indiana.

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NEW BOOKS

Fluid Pressure Mechanisms

H. G. CONWAY, *M.A., A.M.I. Mech. E.* 218 *pages,* 6 x 9 *in. Published by Pitman Publishing Corp., 2 W. 45th St., New York, N. Y.* $5.

This book stresses the operating principles of hydraulic or pneumatic mechanisms and is divided into two parts. The first, entitled "Mechanisms" treats the basic types of equipment used in hydraulic or pneumatic circuits. Among the types discussed are seals, pipe fittings, valves, pumps, motors, cylinders, controls and measuring devices. The majority of the volume is devoted to detailed studies of these components.

The second part entitled "Pressure Systems" contains chapters entitled: Elementary Power Systems, Remote Control Systems, Electric Control Systems and Miscellaneous Systems. In addition, there is an appendix on the history of hydraulic mechanisms.

In writing this book, the author has given attention to the systematic classification of the hydraulic devices treated. For example, in the chapter on valve elements, each type of element is classified as a lift valve or as one of several types of kinematic pairs.

Out of My Later Years

ALBERT EINSTEIN. 282 *pages,* 6 x 9 *in. Published by Philosophical Library, 15 E. 40th St., New York* 16, *N. Y.* $4.75.

The announcement of a new book by Albert Einstein should be of interest to any man engaged in scientific work. This volume will not help you to do your job better or aid one bit in the design of new products, but it is still required reading for a thoughtful engineer.

The volume deals with Mr. Einstein's convictions and beliefs, with public affairs, with well-known personalities in the scientific world, and with some of the most important general concepts of science. All in all there are sixty separate essays. They range from the theory of relativity to socialism. The section on "Science" covers Time, Space and Gravitation, Mechanics and the Attempts to Base all Physics Upon It, The Theory of Relativity, Quantum Theory and the Fundamentals of Physics, The Common Language of Science, The Laws

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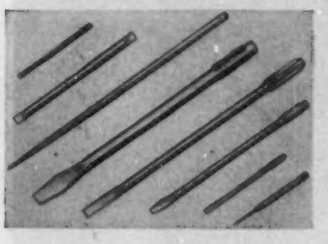

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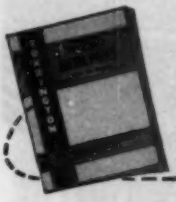

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of Science and the Laws of Ethics, and other such subjects.

Albert Einstein does not belong to that group of scholars who live in the "ivory tower" of their research work, oblivious to the world around them. On the contrary, he has always been an astute and critical observer of the trends and needs of his time. Indeed, frequently did he intervene by written as well as spoken appeal, and always, we should like to emphasize, for a humanitarian cause.

In this sense *Out of My Later Years* mirrors the philosophical, as well as political and social attitudes of its author. The chapters themselves represent addresses, articles, letters, appeals and miscellaneous papers heretofor unpublished.

National Reference Guide For the Patent Field

1950 *Edition.* 50 *pages,* 6 x 9 *in. Published by Paul Field, Port Washington, N. Y.* $2.50.

In this annual publication, a great number of industries are listed together with their main fields of interest, special services and other important details. The book is intended for inventors who wish to find a market for their inventions.

Preceding the company listings is an index in which all the fields of interest named by the companies in their listings are arranged alphabetically. Each entry gives the name of the company or companies specifying the particular field of interest and provides references to the pages on which the listings of these concerns are found. Thus, a user of the "Guide" can conveniently find the listings of companies receptive to the kinds of inventions he wants to submit.

A.S.T.M. Standards On Petroleum Products And Lubricants

Reports of A.S.T.M. Committee D-2 on Petroleum Products and Lubricants. 750 *pages,* 6 x 9 *in. Published by American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.* $5.50.

This latest compilation of A.S.T.M. Standards on Petroleum Products and Lubricants brings together most of the A.S.T.M. standards, test methods, and specifications widely used in this field.

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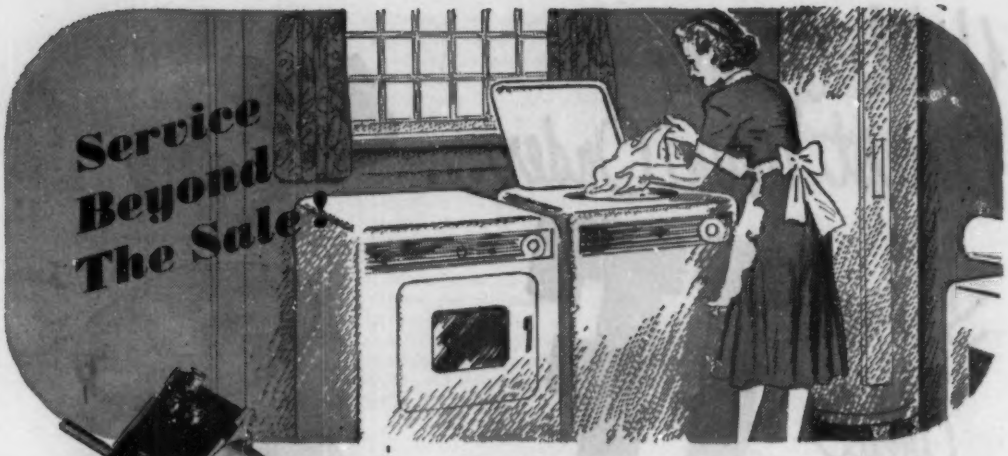

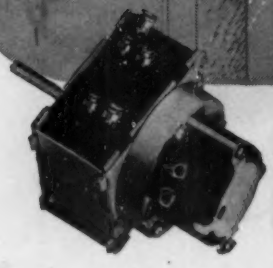

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of definitions relating to petroleum and rheological properties of matter and two tentative recommended practices for the purchase of uninhibited mineral oil for use in transformers and in oil circuit breakers. Covered are motor and aviation fuels; diesel and burner fuels, kerosine and illuminating oils; lubricating oils; greases; petrolatums and paraffin waxes; cutting fluids; electrical insulating oils; light hydrocarbons; hydrocarbon solvents; crude petroleum; and thermometers.

New material includes tentative test methods for: Aniline point and mixed aniline point of hydrocarbon solvents; benzene and toluene by ultra-violet spectrophotometry; hydrogen in petroleum fractions by the lamp method; oleofinic plus aromatic hydrocarbons in petroleum distilates; acetylene in polymerization grade butadiene by silver nitrate method; oxygen in butadiene vapors by manganous hydroxide method; peroxides in butadiene by ferrous-titanous method; sodium in lubricating oils and lubricating oil additives; distillation range of lacquer solvents and dilutents; and tentative methods of testing and standardization of etched-stem liquid-in-glass thermometers.

Appendices include proposed methods of test for: Determination of microcone penetration of lubricating grease; apparent viscosity of lubricating greases; sulfur in petroleum products by the CO_2-O_2 method; bromine number of petroleum distillates (color indicator method and electrometric method). Also included are proposed definitions, functions, types and designations of cutting fluids; carburetor jacket for use with motor and research methods to rate high vapor pressure fuels; method for determination of color index of petroleum products by photoelectric colorimeter; and measuring the temperature of petroleum and petroleum products. There are also recommendations on the form of A.S.T.M. methods of test for petroleum products and lubricants.

Phenomena, Atoms and Molecules

IRVING LANGMUIR, *winner of the Nobel Chemistry Award in* 1932. 436 *pages,* 6 x 9 *in. Published by Philosophical Library,* 15 E. 40*th St. New York* 16, *N. Y.* $10.

As stated in the subtitle, this volume is an attempt to interpret phenomena in terms of mechanisms or atomic and molecular interactions. Its eighteen chapters contain a collection of twenty papers, which is roughly about one-tenth of the papers that the author has

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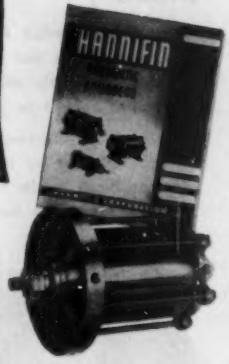

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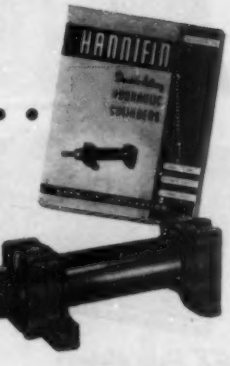

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A bibliography at the end of the book contains a list of papers published by the author. This extensive list is arranged in eight groups according to the principal subject matter treated.

Electrical Engineers' Handbook

Electric Power

Edited by HAROLD PENDER, *Dean of the Moore School of Electrical Engineering, University of Pennsylvania, and* W. A. DEL MAR, *Chief Engineer, Habirshaw Cable and Wire Division, Phelps Dodge Copper Products Corporation. Fourth Edition,* 5¼ x 8¼ *in.,* 19 *sections. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.* $8

While this is technically the Fourth Edition of the Electrical Engineers' Handbook, it represents only the second edition since the book was split into two sections—one on Electric Power, and one on Electric Communication and Electronics. As with other editions, the book is the work of 71 specialists in various fields of electrical engineering. Each section has been entirely rewritten. There are 19 in all: (1) Mathematics, Units, and Symbols; (2) Properties of Materials; (3) Electric Circuits and Electric Lines; (4) Principles of Electro-Chemistry; (5) Measurements and Measuring Apparatus; (6) Resistors, Rheostats, Capacitors, Reactors, Electromagnets and Permanent Magnets; (7) Batteries; (8) Direct-Current Machines and Rotary Energy Converters; (9) Alternating-Current Generators and Motors; (10) Transformers; (11) Power Rectifiers and Inverters; (12) Switchgear

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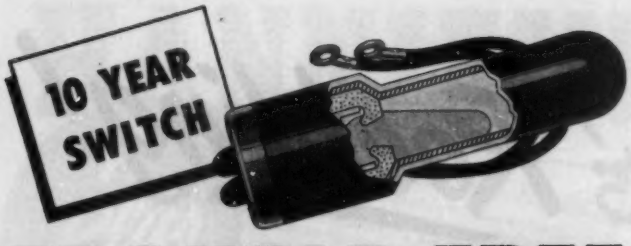

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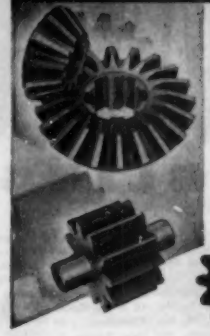

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Whereas in the Third Edition one author covered all types of rotating machinery, this edition has five authors discuss the various phases of that subject. Consequently, it is a more closely knit and compressed volume than the previous ones.

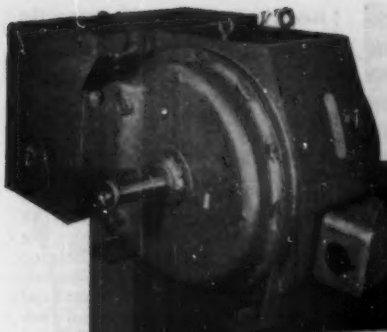
Theory and Design Of Gas Turbine and Jet Engines

E. T. VINCENT, *Professor of Mechanical Engineering, University of Michigan. 606 pages, 6 x 9 in. Published by McGraw-Hill Book Company, 330 W. 42 St., New York 18, N. Y. $7.50.*

In many fields of engineering, design is based on empirical formulas or on analytical data that is regarded as the property of the concern that has developed it. A company develops design methods, chart data and empirical equations based on test results obtained with actual machines, and then feels reluctant to release such data for general use because of the excellent competitive position it places them in. Whether this is good or bad from the viewpoint of the concern involved is subject to debate. There is no question, however, that this tendency retards general progress in the specific field. An example is the field of steam turbine design. One of the earliest texts in this field—that authored by Stodola—remained one of the best for a long period of time. Even today, detailed data for steam turbine design is closely guarded by the company that develops it.

What is true of steam turbines is also true of the much newer—and more spectacular—gas turbines, particularly as they apply to our aircraft. So it is that when Professor Vincent undertook a basic text on gas turbines and jet engines. That he fairly well accomplished his purpose, therefore, is very much to his credit, especially when advanced data on the subject is still pretty much in the proving ground stage and other data are yet to be released because of security reasons.

The book, as written, is intended as a text for the undergraduate or college graduate student. It is not an advanced handbook for the designer of supersonic aircraft engines. It is, however, a basic text, a thorough under-



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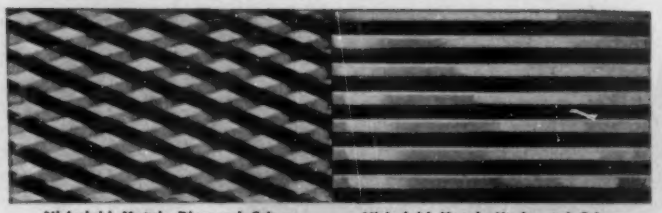

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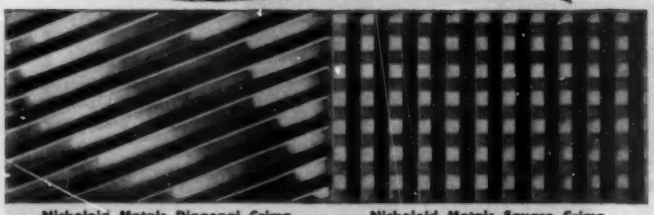

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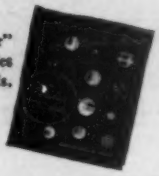

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standing of which would advance the reader a long way into the subject, and as a reference on the fundamentals upon which design is based, it should prove very useful. There are 18 chapters: (1) Some Thermodynamic Principles; (2) Fundamentals of Gas Flow; (3) Jet Propulsion; (4) Power Plant Cycles; (5) Jet-Propulsion Design; (6) The Turbine Power Plant; (7) Performance Characteristics; (8) Typical Power Plants; (9) The Fundamental Principles of Rotating Machines; (10) Centrifugal Compressors; (11) The Design of Centrifugal Compressors; (12) The Axial-Flow Compressor; (13) Design of Axial Compressors; (14) Turbine Theory; (15) Turbine Design; (16) Combustion Chambers, Fuel Systems and Fuels; (17) Materials; (18) Regenerators.

The chapters on types of compressors and compressor design, Numbers 10-13, inclusive, are good, as is the group on gas turbine design and performance. Of somewhat broader interest is the description of various jet-propulsion devices, Chapter 5. The remaining chapters are somewhat more fundamental in nature, especially the review material on thermodynamics and heat power.

This new book is designed to provide a text in the field of gas turbines, in which the theory and practical application of this theory to specific design problems are presented. The idea of an impulse or reaction, for example, is treated theoretically, but this is followed by the two types so necessary for success in practice. The limitations imposed on the flow-type of combustion processes have been developed, as well as some of the conditions of shock and choking.

A book of this sort is very difficult to keep up to date. The field is moving too rapidly. But as a definite step on the way, the book should receive the close attention and analysis not only of the specialist responsible for college engineering curricula, but also of designers in the field.

Reflections of a Physicist

P. W. Bridgman, *Harvard University*. 392 *pages*, 6 x 9 *in. Published by the Philosophical Library*, 15 *E. 40th St., New York* 16, *N. Y.* $5.

This collection comprises the bulk of the non-technical writings of Dr. Bridgman together with three papers here published for the first time. The topics range over a considerable field, but there is a certain unity in the treatment in that the "operational" approach is used throughout. It is this approach which has made possible the

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successes of modern physics in meeting revolutionary new physical situations. The present collection may be regarded as an extension of the operational approach to problems in other fields than physics, including those problems created by the increasingly important social role which science is coming to play.

A sampling of the chapter headings will give some idea of the scope of the book. Some of these headings are: Some General Principles of Operational Analysis, Science: Public or Private?, Statistical Mechanics and the Second Law of Thermodynamics, On the Nature and the Limitations of Cosmical Inquiries, The Struggle for Intellectual Integrity, "Manifesto" by a Physicist, Scientific Freedom and National Planning, The Prospect for Intelligence, and New Vistas for Intelligence. Three of the papers are here published for the first time: The Strategy of the Social Sciences, Scientific Freedom and National Planning, and Sentimental Democracy and the Forgotten Physicist.

The Organization of Industrial Scientific Research

C. E. KENNETH MEES *and* JOHN A. LEERMAKERS. 383 *pages, 6 x 9 in. Published by The McGraw-Hill Book Company,* 330 W. 42nd *St., New York* 18, *N. Y.* $5.

This second edition is essentially a new book; the first edition was published in 1920. The text presents an account of the history and development of industrial scientific research, the general principles of its conduct, and an analysis of the methods actually used for the organization and operation of industrial research laboratories.

The authors have selected material that will be of value not only to those engaged in the conduct of industrial research but also to the business executives who are concerned with the operation of departments responsible for research and development. In addition to their own experience, the authors have been able to make use of much material supplied by many others engaged in the direction of industrial research.

Divided into three parts dealing with general principles, agencies for the conduct of industrial research, and the organization and operation of industrial laboratories, respectively, this revised edition covers all steps in the organization and operation of an industrial research laboratory.

Included in the volume are descriptions of the setup of such agencies as

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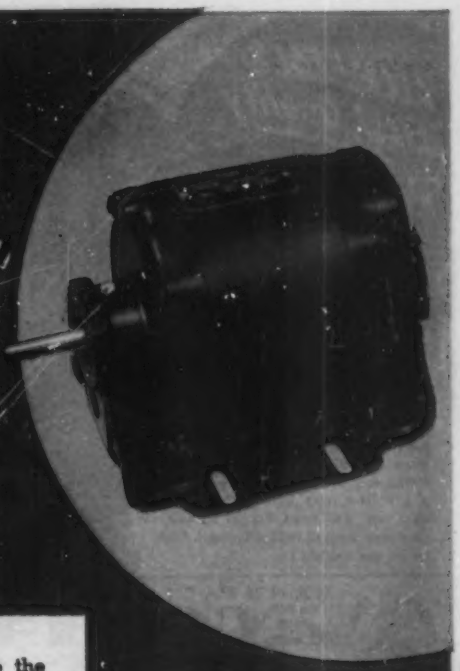

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government laboratories, research associations, technological research institutes, and industrial laboratories. Detailed information is provided on the selection of the program, the direction of research, the financial administration of the laboratory, and auxiliary services.

Engineering Structures

Symposium at the University of Bristol in September 1949 *which was sponsored by the Colston Research Society.* 260 *pages,* 7 x 9¼ *in. Published by Academic Press Inc., New York, N. Y.* $4.

The objective of this Symposium was to bring together research workers from a number of different fields to present the results of their recent studies concerning the problems of engineering structures. Whether for bridges, buildings, ships, or aircraft, these structural problems are fundamentally similar.

In choosing the subjects, emphasis has been placed on problems which have been associated with non-linearity in structural behavior. This aspect of design is especially important at the present time, for this characteristic has been observed in members having large deflections and also, in cases where plasticity or creep has occurred.

Following an introductory talk by R. V. Southwell on *Current Trends in Structural Research,* the following papers were presented.

1. *Carrying Capacity of Simply Supported Mild Steel Beams.*

A historical review is given of the investigations of loading beams beyond the yield point. The testing done in this study verified the plastic behavior of a member subjected to pure bending. The stress concentration produced in the region of load application was found to seriously affect the load capacity of beams.

2. *Performance of Laterally Loaded Channel Beams*

Channel shapes, made from cold-formed light-gage steel, are the most economical of the flanged type; however, this member has a tendency to twist when loaded in the plane of the web. This article describes the work at Cornell University where the use of external bracing was studied. The localized maximum stress was found not to govern the strength of this structural member because of plastic deformation.

3. *Experiments on the Flexure of Rectangular Box Girders of Thin Steel Plates*

This paper is a progress report of an extensive experimental program. It covers the results of seven tests on

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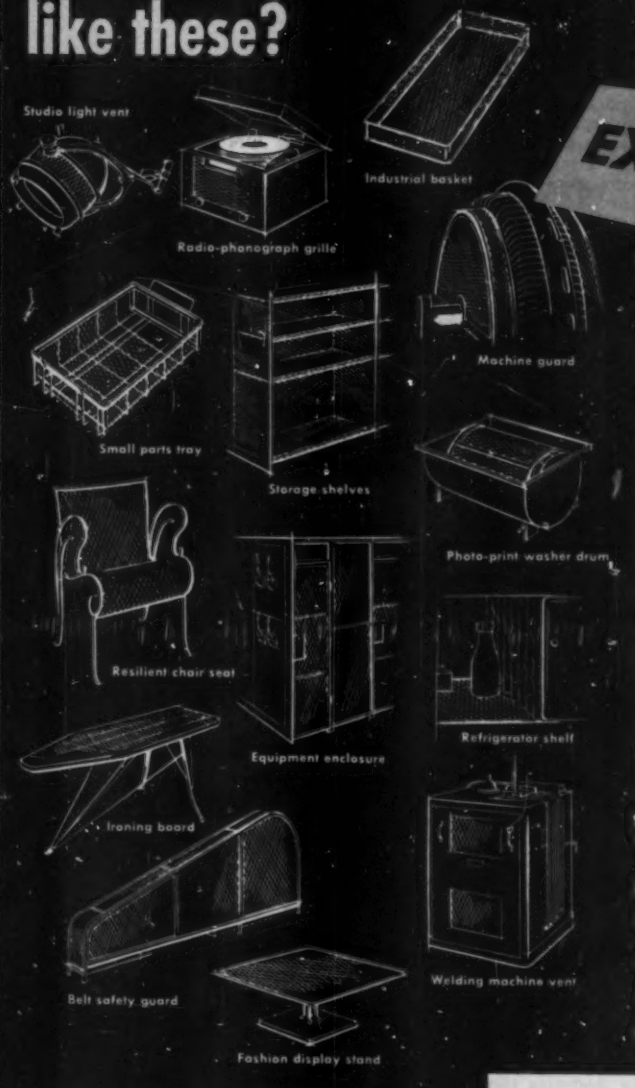

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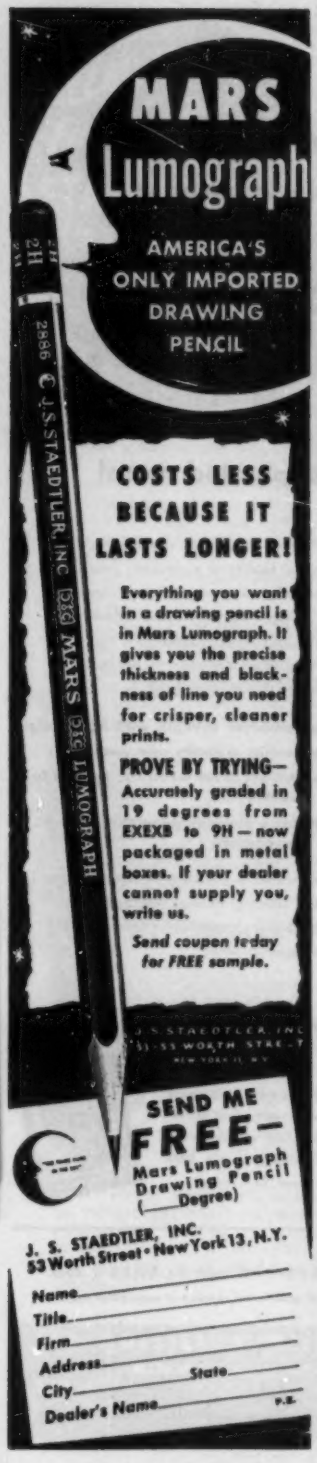
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4. *Plastic Deformation of Rectangular Plates Under Direct Loads*

A plastic flow theory is given mathematically for small deformations of rectangular plates under uniform direct loads applied to all edges. This theory is an extension of recent work on the plastic flow theory of buckling of plates under compressive loads and the Shanley inelastic column theory.

5. *Strut in a Non-linear Medium and the Waves in a Tension Field Shear Web*

The waving of a shear web in a well developed tension field condition has not received much detailed attention. This paper sets forth the theory and discusses the wave-length and amplitude of the web buckles. The tension and compression stresses along and across these buckles are also examined.

6. *Dynamic Criteria of Buckling*

The usual criterion of buckling cannot be rigorously maintained in systems which are non-linear or not perfectly elastic. This paper suggests that such systems be investigated by determining their motion following a disturbance. If the structure returns reasonably close to its original position in a reasonable time, the system should be considered stable. Some examples are worked out with the aid of single degree of freedom models.

7. *Effect of Variable Repeated Loads in the Plastic Theory of Structures*

In the plastic theory of structures, it is usual to estimate the ultimate carrying capacities by considering the most severe load distribution only. When loads are continually varied a large number of times to the same structure, the ultimate capacity may be reduced. This paper gives a theoretical treatment which is based on an idealization of the behavior of steel under alternating stresses.

8. *The Shortening Effect Feature in Pure Torsion*

An analysis is given to illustrate how longitudinal stresses arise from the shortening effect of pure torsion. After describing the existing analyses of this problem, the analysis is applied to thin-walled structural sections. Two sets of experiments undertaken to verify the accuracy of this analysis are described.

9. *Effective Stiffness of Stringers to Locally Applied Loads*

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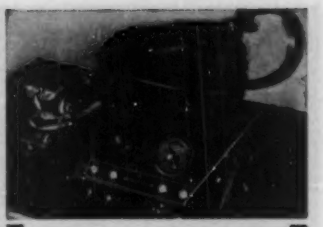

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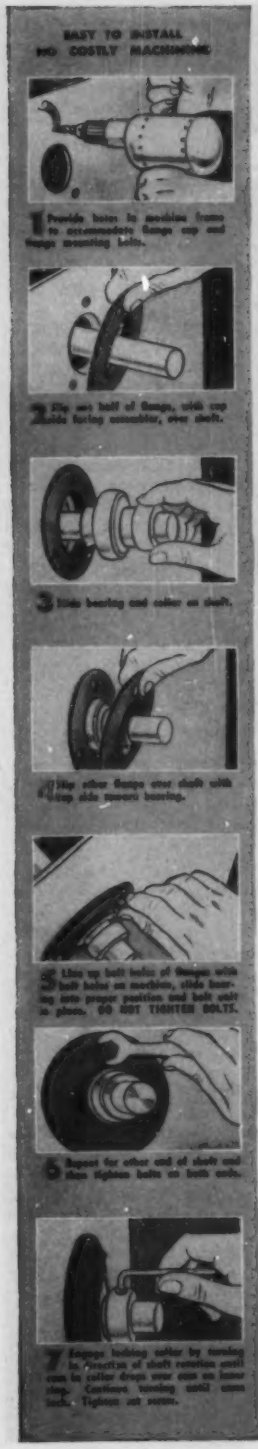

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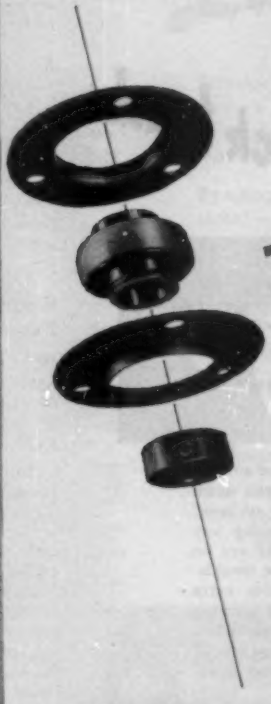

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Now you can add ball bearing performance, power economy and longer bearing life to your equipment within your cost limits. A brand new, simple, low cost housing idea eliminates costly machining, makes maintenance easier. A pair of pressed steel flanges which can be bolted anywhere on your machine, provides a lightweight, compact, sturdy housing for a standard Fafnir Wide Inner Ring Ball Bearing. Curved contour of inside surface of flanges matches curving contour of bearing outer ring to provide full self-alignment when installing the unit. A twist of the collar locks bearing to shaft. Sealed both sides with Fafnir Mechani-Seals . . . a labyrinth design of interlocking steel plates. Write today for illustrated folder. The Fafnir Bearing Company, New Britain, Conn.

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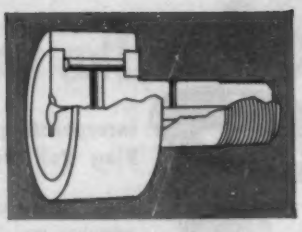

You can see at a glance the ruggedness of construction which enables Multirol CF Series bearings to take repeated shock loads, even at the increased speeds demanded by modern machines. The extra heavy outer race section has a case hardened surface which provides extra wear, and a tougher core to resist shock loads. The inner race and flange, with hardened wear surfaces, are made of a single piece with the stud, preventing any possibility of disassembly in operation. Notice there are no delicate parts or washers anywhere, to break or cause trouble. The many full type small diameter rollers provide extra bearing surface. They are finished to precision limits assuring friction-free operation between the smooth ground raceways. Nearly twenty years successful operation in a variety of installations has proved the quality, construction and workmanship of CF Series Multirol bearings.

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precision bearings

feners indicate a need for a better understanding of buckling. This paper outlines the way the foundation stiffness and the wrinkle wave-length are affected by localized conditions of loading.

10. *Compression Plates as Parts of Structural Members*

This paper reviews recent investigations of the behavior of compression plates as a part of a structural member instead of an isolated plate.

11. *Investigation of Aluminum Alloy Riveted Joints under Static Loading*

This paper deals with the behavior of riveted joints which are either axial or eccentrically loaded and designed to neglect frictional effects. The theory discussed is also confirmed by experiments.

12. *Design of Structures on the Basis of Assumed Deformations*

This design procedure is more or less an inversion of the usual method used for redundant structures. Method has the advantage of avoiding the complicated calculations in determining the redundant quantities in highly indeterminant structures. It is particularly practical in structures where specific deformations are desirable.

Electronics: Experimental Techniques

W. C. ELMORE *and* MATTHEW L. SANDS, 417 *pages, 6 x 9 in. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y.* $3.75.

This volume describes the most useful and the successful circuits for making nuclear and other physical measurements. These circuits should prove useful to students and research workers in laboratories.

In addition to the description of complete circuits—pulse amplifiers, counting circuits, sweep circuits, timing circuits, testing equipment, etc.—the book contains a discussion of the circuit elements that constitute the basis of complete circuits.

Many of the circuits described are being widely used in physics research today and this book constitutes a manual of these circuits. In addition, it gives an excellent background for the design of new circuits.

The authors were members of the Electronics Group, a subdivision of the Los Alamos Laboratory. During development of the atomic bomb, this group devised circuits for the specific requirements of the various research groups involved in the Manhattan Project.

Basically this book is a collection of the most important circuits developed

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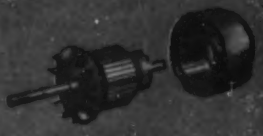

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during that time. Complete descriptions and theoretical discussions are included for each circuit. Sample chapters are: Electronic Counters, Circuit Components and Construction Practice, Voltage Amplifiers, Power Supplies and Control Circuits.

Industrial Electronic Control

W. D. COCKRELL, *Industrial Engineering Division, General Electric Company, Second Edition.* 385 *pages,* 6 x 8 *in. Published by McGraw-Hill Book Co., Inc.,* 330 *W.* 42*nd St., New York* 18, *N. Y.* $4.

This volume explains the fundamentals of electron-tube operation and shows how it is applied in the basic circuits used in present-day industrial electronic control.

In a practical, nonmathematical treatment it covers the various types of electron tubes, fundamental circuit components, basic electronic circuits, and many complicated circuits which are typical of modern industrial practice.

In this second edition, all wiring diagrams have been redrawn to agree with the new ASA Industrial Electronic Symbols. Useful information on many circuits, such as counters, clamps, switches, and gates, has been included, as have typical industrial circuits in use in the field of instrumentation and motor control.

Of great value to the industrial electronic engineer will be the simple explanation of the use of electronics in closed-cycle controllers, sometimes called feedback amplifiers or servomechanisms.

The new ASA graphical symbols for inductance and capacity have been adopted, and a list of questions has been placed at the end of each chapter for use in review when the book is used as a classroom text. The reference lists have been revised and enlarged.

Perhaps the most important addition has been a new section on closed-cycle control, or regulating systems. Recent work in the Bell Laboratories, the M.I.T. Servomechanism Laboratory, and elsewhere has brought the understanding of regulating and hunting actions from the realm of the graduate mathematician to that of the practicing electronic engineer.

Typical sections include: Electron Tubes, Circuit Components, Basic Electronic Circuits, Closed-Cycle Control Systems and Industrial Electronic Circuits. A 40-page Appendix includes: Nomenclature, Standard Curves, Rectifier Wave Shapes, Photoelectric Phenomena and Closed-Cycle or Regulating Systems.

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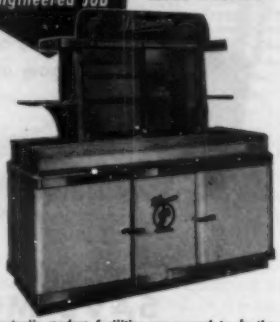

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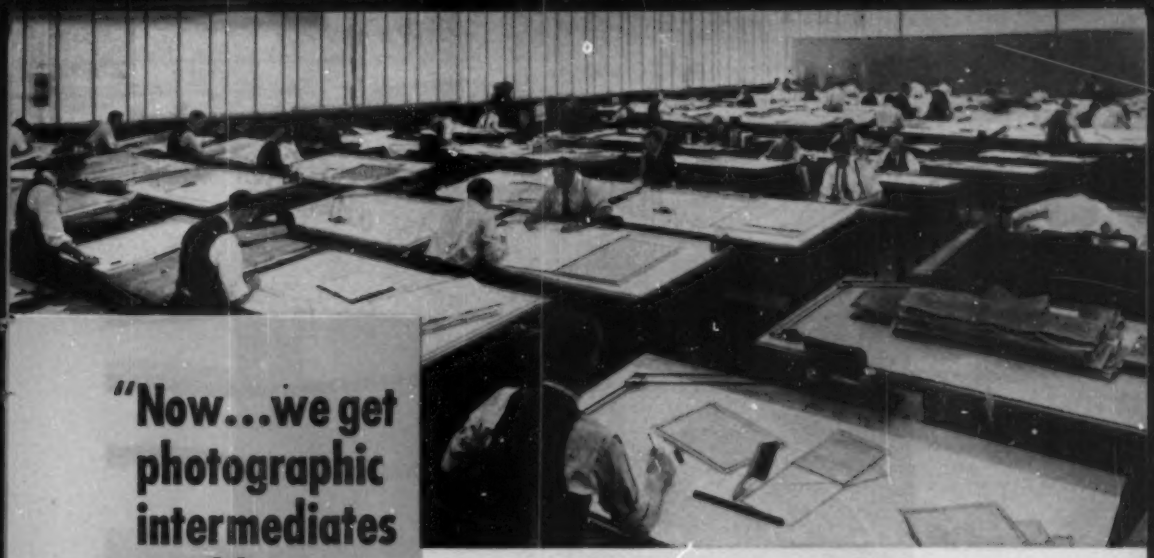

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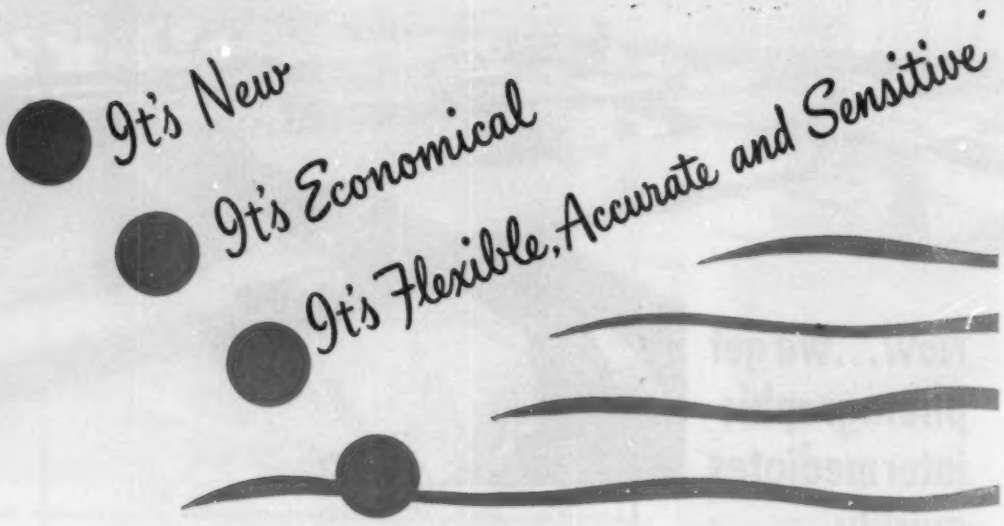

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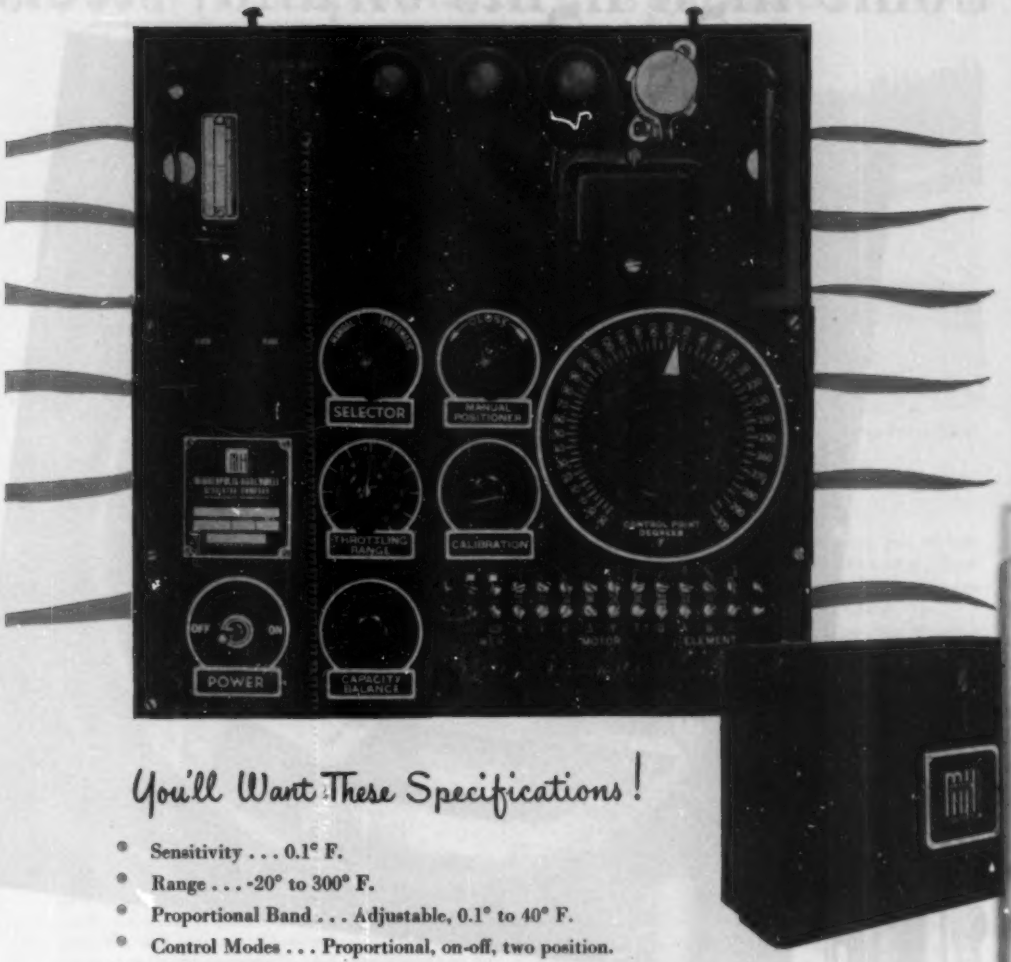

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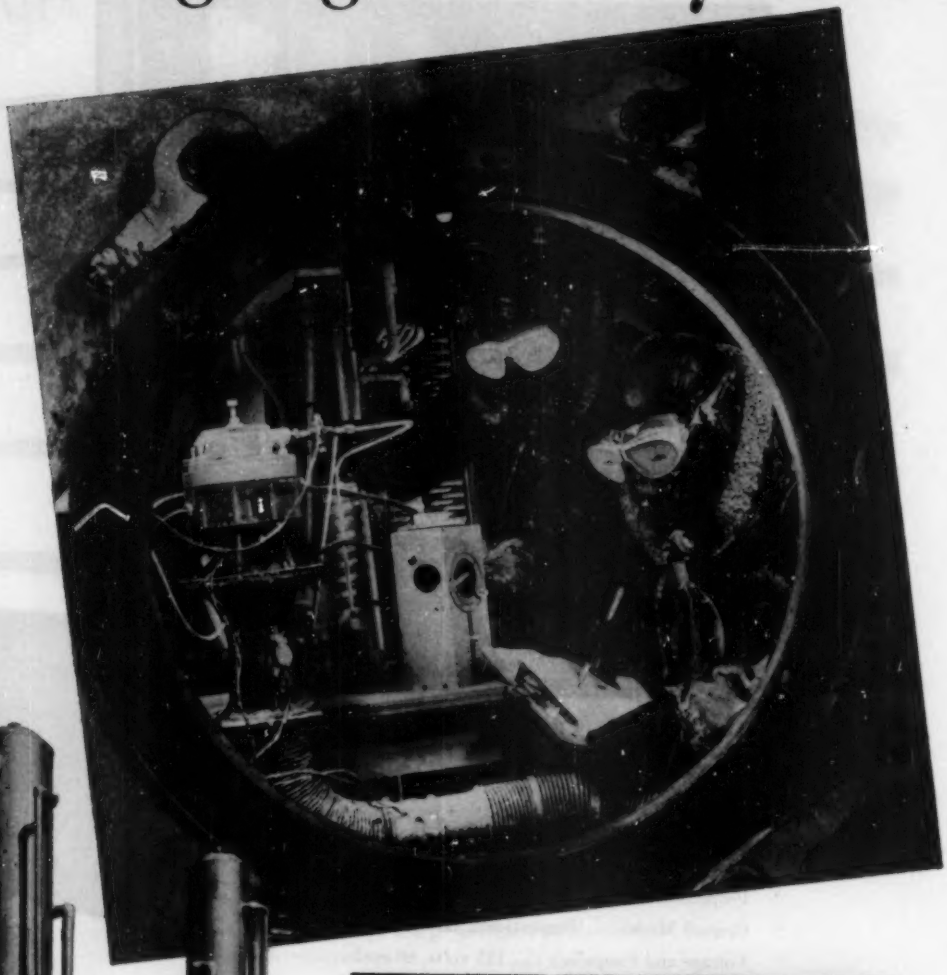

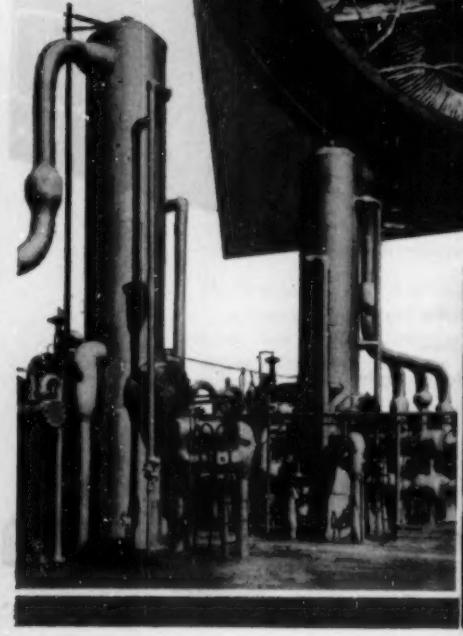

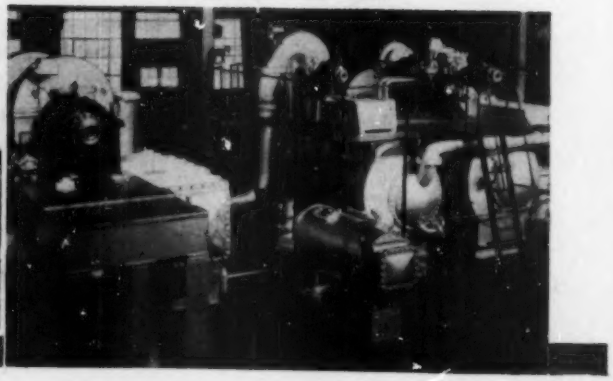

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IN recent years, steels for low temperature service have been receiving more and more attention. And deservedly so.

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The property which is most affected by low temperatures is resistance to shock or impact. At sub-zero temperatures, the mechanical properties of steel generally change as the temperature is lowered. Such properties as ultimate tensile or yield strengths generally will increase. However, the impact properties may, and frequently do, drop more than would be satisfactory if severe shocks were imposed.

Plain carbon steels are highly susceptible to embrittlement at extremely low temperatures. Low carbon nickel-alloy steels, however, offer higher resistance to shock under these conditions.

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NEW CATALOGS AND BULLETINS

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(1) **ALUMINUM CASTING ALLOY** — William F. Jobbins Inc., P. O. Box 230, Aurora, Ill. Bulletin, 10 pp. Gives pertinent engineering data on Almag 35, aluminum casting alloy, as to physical properties, machinability, corrosion resistance, stress corrosion, surface finish and temperature effects. Mold and die casting applications are included.

(2) **ALLOY STEELS**—Joseph T. Ryerson & Son, Inc., Box 484, Jersey City 3, N. J. Bulletin, 4 pp. Engineering information on Rycrome and Nikrom "M" steels is given with examples of applications. Mechanical properties, creep strengths, temperature effects and machinability ratings are set forth.

(3) **ELECTRONIC AND COMMUNICATIONS EQUIPMENT**—The Radio Shack Corp., 167 Washington St., Boston, Mass. 1950 catalog, 152 pp. Lists, describes, and gives technical and price information on this distributor's line of electronic and communications equipment, covering industrial electronics, television, music systems, recording, testing and research. The listing includes completed equipment, kits, components, hardware, tools, test equipment and a book section.

(4) **SELENIUM POWER RECTIFIERS** —Accurate Engineering Co., 3006 Blue Island Ave., Chicago 8, Ill. Bulletin 300, 16 pp. Selenium rectifier theory is briefly covered and manufacturer's line of rectifiers is described, with pictures, charts, and circuit diagrams of each unit.

(5) **DIESEL FUELS AND LUBRICANTS** —Sinclair Refining Co., 630 Fifth Ave., New York 20, N. Y. Bulletin, 46 pp. Illustrated with charts, diagrams, and cutaway views, describing the history and operation of the diesel engine with a review of fuels and lubricating oil systems and a survey of diesel fuels and lubricating oils.

(6) **PACKAGING AND PAPER LACQUERS**—Hercules Powder Co., Wilmington, Del. Bulletin, 32 pp. This basic booklet on nitrocellulose packaging and paper lacquers is illustrated with charts and graphs and gives descriptions of the formulations and materials used in the company's research and detailed results of the investigations.

(7) **INSULATION HARDBOARD**—Great American Industries, Inc., Rubatex Div., Bedford, Va. Bulletin RBH 1-50, 16 pp. Gives design data on Rubatex R-108-B Insulation Hardboard, together with heat flow charts and calculations, and charts for correct application of this insulating compound.

(8) **METAL CLEANING**—Oakite Products Inc., 22 Thames St., New York 6, N. Y. Bulletin, 44 pp. After describing the wide variety of metal soils and their possible causes, this booklet discusses specific materials, equipment and procedure for the removal of each. Other industrial cleaning problems are also covered.

(9) **VIBRATORY FEEDERS** — Syntron Co., Box 320, Homer City, Pa. Bulletin, 14 pp. Describes special vibratory feeders powered by standard magnet units. Pictures and descriptions of feeder installations are given together with necessary technical data.

(10) **BEARINGS AND MAINTENANCE BARS**—The Buckeye Brass and Mfg. Co., 6410 Hawthorne Ave., Cleveland 3, Ohio. Catalog 480, 40 pp. Listed are the part numbers, dimensions, tolerances and metal analyses of bronze sleeve bearings and maintenance bars. Bearing drilling and grooving and graphite bearings are discussed.

(11) **INDUSTRIAL PLASTIC**—Westinghouse Electric Corp., E. Pittsburg, Pa. Bulletin, 25 pp. Explains how the industrial plastic Micarta is manufactured and used. The physical and chemical properties of Micarta are fully charted and graphed. Design suggestions are included.

(12) **SALT WATER AND METALS**—The International Nickel Co., 67 Wall St., New York 5, N. Y. Bulletin, 17 pp. Entitled "When Metals Go to Sea," this booklet describes the effects of and remedies for salt water and salt air corrosion in the language of the layman, understandable to non-metallurgical personnel.

(13) **VARIABLE SPEED PULLEY** — Reeves Pulley Co., Columbus, Ind. Catalog V-498, 27 pp. Gives descriptions and operating principles of the Vari-Speed Motor Pulley with illustrations. Installations are pictured and charts are offered for V-belt ratings and standard pulley dimensions.

(14) **ANTI-CORROSION COATING**—Bisonite Co., 126 Lakeview Ave., Buffalo 1, N. Y. Data Sheets, 15 pp. Describes Bisonite "M", an anti-corrosion coating of inert thermoplastic resins. The physical and chemical properties are listed together with methods of application. Specific chemical resistance tables are included.

(15) **BEARINGS AND CASTINGS** — American Brake Shoe Co., National Bearing Division, 4930 Manchester Ave., St. Louis 10, Mo. Bulletin, 37 pp. This bulletin gives a description of the design and manufacture of bronze and copper bearings and castings. Corrosion recommendations and a data chart of bearing metals are included.

(16) **ELECTRIC MOTORS**—The Emerson Electric Mfg. Co., St. Louis 21, Mo. Bulletins 110-F, 111-F, 112-F, 114-F, 118-F and 204, 29 pp. Describe the construction features, specifications and dimensions of split phase, capacitor start, integral horsepower, jet pump, oil burner, and fan duty electric motors. Charts, graphs and photographs.

(17) **LUBRICATION SYSTEMS** — The Lincoln Co., 5701 Natural Bridge Ave., St. Louis 20, Mo. Bulletin, 8 pp. Illustrates a line of lubricating systems with pictures of applications and charts and diagrams of mining, construction and process machinery lubricating systems. Lubricating tools are also shown.

(18) **ALLOY STEELS**—Joseph T. Ryerson and Son, Inc., Box 484, Jersey City 3, N. J. Bulletin, 24 pp. Explains how to specify and buy alloy steel. Tests and heat treatments are covered. A condensed list of steel alloys is included.

(19) **WIRED TELEVISION** — Diamond Power Specialty Corp., Lancaster, Ohio. Bulletin 1026, 16 pp. "Wired Television"

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is explained with its applications for remote observation on processes too remote, too inaccessible, or too dangerous for direct observation.

(20) SAFETY AND RELIEF VALVES—Kunkle Valve Co., 119 S. Clinton St., Fort Wayne 2, Ind. Catalog 43, 32 pp. Gives dimensions, diagrams, pictures, features, specifications and service recommendations for safety and relief valves for use with steam, air and liquids from 15 to 4,000 psi.

(21) VIBRATION METERS — The Calidyne Co., 751 Main St., Winchester, Mass. Bulletin 11, 6 pp. Standard known-potential sources, vibration meters, acceleration meters, acceleration calibrators, vibration recorders and ride recorders are specified and described.

(22) HEATER ELEMENTS — Acra Industrial Electric Co., 3001 N. Ravenswood Ave., Chicago 13, Ill. Bulletin, 16 pp. This is a guidebook for the application of heating elements used in production and industry. Heat transmission data and problems are included, together with heater element, thermostat and heater specifications.

(23) AIRCRAFT INSTRUMENT EQUIPMENT—Lear Inc., 110 Ionia Ave., N.W., Grand Rapids 2, Mich. Bulletin B-102, 8 pp. Pictures, diagrams, charts and design data on servo actuators. Bulletin on automatic VHF navigator also offered.

(24) SLITTING LINES FOR COILS AND SHEETS—The Yoder Co., 5500 Walworth Ave., Cleveland 2, Ohio. Bulletin, 74 pp. Basic information on design, selection, and operation of slitters and slitting lines. Also included are specifications, capacity tables, and other data on metal sheet coil processing equipment.

(25) INDUSTRIAL WIRE CLOTH — Reynolds Wire Co., Dixon, Ill. Bulletin, 7 pp. Gives available wire sizes, mesh openings, metal alloys, protective coatings, applications, and ordering information on wire cloth.

(26) COMMERCIAL REFRIGERATION —The Bush Manufacturing Co., W. Hartford 10, Conn. Catalog 350, 48 pp. Gives engineering information with sample calculations and charts, together with dimensions and specifications for commercial refrigerating equipment.

(27) PRECISION CASTINGS — Alloy Casting Div., Michigan Steel Casting Co., 1999 Guoin St., Detroit 7, Mich. Bulletin, 12 pp. Describes the advantages, methods and tolerances of precision carbon and stainless steel castings. Micro-photographs and engineering properties of castings are shown. Casting dimensioning explained.

(28) RUBBER-LINED PIPE, FITTINGS AND VALVES—B. F. Goodrich Co., Akron, Ohio. Catalog 9786, 8 pp. Gives instructions for specifying and descriptions of the construction of rubber lined pipe and fittings. Recommendations for pressure and corrosion qualities are listed.

(29) WATER JET EDUCTORS—Schutte and Koerting Co., 12th and Thompson St., Philadelphia 22, Pa. Bulletin 22M, 35 pp. Dimensions, prices and capacities of water jet eductor line. Color illustrations and operation, construction and application explanations are given for specific eductors and liquid pumping systems.

(30) COLD ROLLED SPRING STEELS —Sandvik Steel, Inc., 111 Eighth Ave., New York 11, N. Y. Catalog 50, 31 pp. The raw material, manufacturing processes, and specifications of spring steel are explained. Tables of available spring steel coils are given, with weight and hardness tables.

(31) RUBBER TANK LININGS—B. F. Goodrich Co., Akron, Ohio. Catalog 9020, 6 pp. Process for bonding rubber to metal and materials used are described and illustrated. Tables show chemicals which can be handled in rubber lined tanks.

(32) CUSHIONED CLAMPS — Thomas Associates, 4607 Alger St., Los Angeles 39, Calif. Bulletin 1950, 28 pp. Line drawings, tabulated data, and text explain construction, sizes, and uses of clamps made with a variety of cushioning materials. Clamps may be cushioned with Neoprene, with a conductive rubber, a high temperature cushion, fire resistant cushion, and for other special uses.

(33) MERCURY MANOMETER FLOW METERS—Fischer & Porter Co., Hatboro, Pa. Catalog 37, 11 pp. Diagrams and explanations of mercury manometer flow meters. Engineering specifications, together with application data also supplied.

(34) INDUSTRIAL POWER PUMPS—John Bean Div., Food Machinery and Chemical Corp., Lansing 4, Mich. Bulletin, 28 pp. Pictures of pump applications and cutaway views. Specifications and dimensions given for pumps handling from 1 to 76 gpm at pressures up to 6,000 psi.

(35) PNEUMATIC THROTTLING OPERATORS—Consolidated Corp., 2100 Arch St., Philadelphia 3, Pa. Bulletin 104, 8 pp. Describes design, operation and applications of pneumatic positioning devices for throttling control. Includes information on "Rotometer" using screw mechanism and pneumatic motor.

(36) AIRFLEX COUPLINGS—The Falk Corp., Milwaukee 8, Wis. Bulletin 5100, 7 pp. Pictures and dimensions of improved air cushion flexible coupling, for use from 100 to 6,000 rpm. Operating principles, applications, and vibration characteristics discussed.

(37) SAFETY RELIEF VALVES — Marine and Industrial Products Co., 2721 Filbert St., Philadelphia 6, Pa. Bulletin 250. Contains test data and charts, together with capacity tables of safety valves for pressure reducing regulators from 10 to 500 psi.

(38) OIL PUMPS AND MOTORS—Sundstrand Pump Div., Sundstrand Machine Tool Co., Rockford, Ill. 2 bulletins, 16 pp. Describes hydraulic pumping unit, fluid motor, and variable speed 1½ hp power transmission. Pump ratings from 5 gpm at 250 psi to 18 gpm at 500 psi. Motor speeds vary from 10 to 1,200 rpm.

(39) CONSERVATION VENT VALVES AND UNITS—The Vapor Recovery Systems Co., Compton, Calif. Bulletin, 7 pp. Contains flow charts, dimensions, and prices of vent valve units for venting inflammable liquid storage tanks. Flame arrester portion of the unit is explained.

(40) SHOCK CONTROL MOUNTS—The Barry Corp., 170 Sidney St., Cambridge, Mass. Catalog 503, 7 pp. Describes a line of mounting units for vibration and shock control. Individual mounts and mounting bases shown.

(41) CONDENSERS — Condenser Service & Engineering Co., Inc., Hoboken, N. J. Bulletin, 27 pp. Covers a line of steam condensers with explanations, diagrams, and engineering tables. Maintenance and application treated. Air ejection is also covered.

(42) STEEL COUPLINGS — The Falk Corp., Milwaukee 8, Wis. Bulletin 4100, 30 pp. Gives selection, dimensioning and ordering instructions for all-steel flexible couplings for 7.5 to 3,600 rpm and ½ to 300 hp. Vibration constants tabulated.

(43) CENTRIFUGAL AND PISTON PUMPS—Condenser Service & Engineering Co., Inc., Scranton Pump Div., 1445 Mayfert Ave., Scranton, Pa. Bulletin, 32 pp. Covers a line of pumps operating at from 1,500 to 3,600 rpm with capacities to 3,000 gpm.

HOW TO ORDER—Two post cards are printed here. On each is room for you to request four pieces of literature. If you are requesting four pieces or less, please use only the bottom card. For five to eight pieces use both cards.

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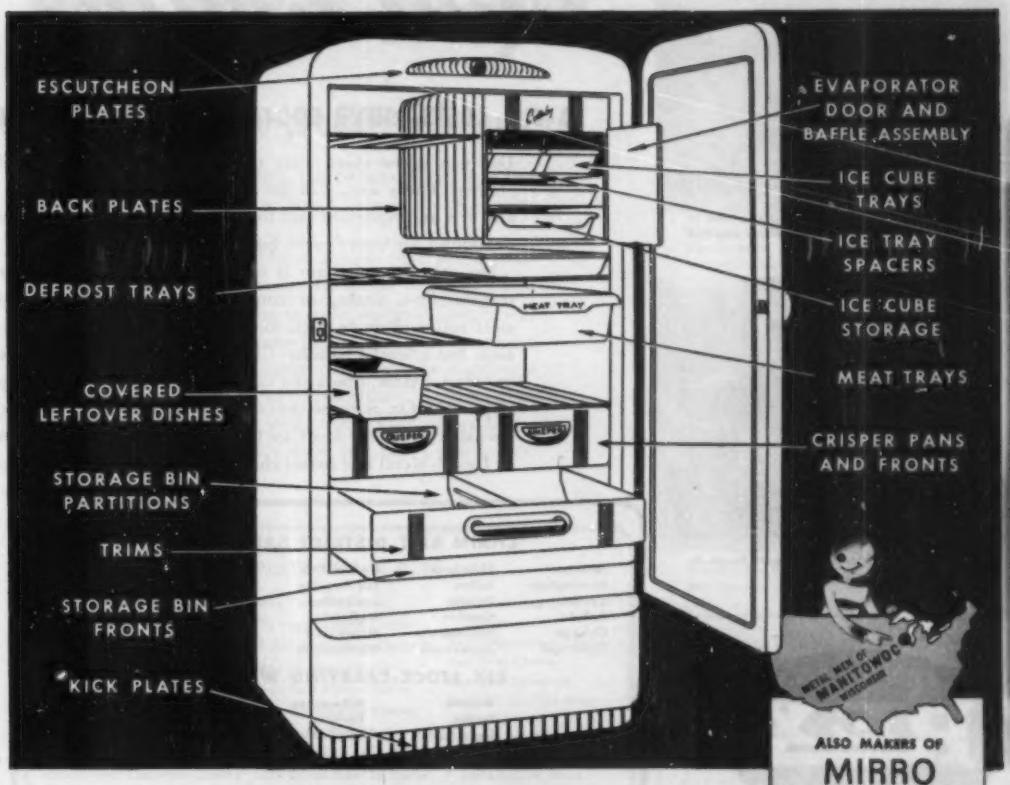

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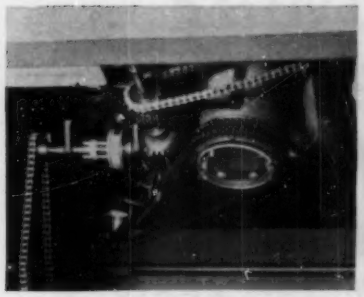
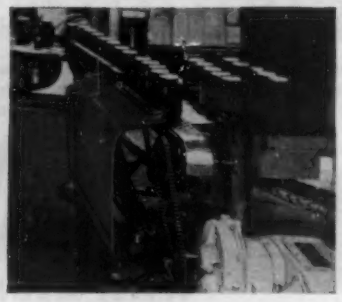
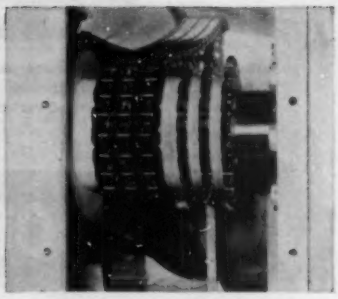


Baldwin-Rex ¼-inch pitch Roller Chain is used to transmit power in this micro-film reader.



Rex Table Top Chain handles bottles through this filling machine.



Both Rex Offset Side Bar Roller Chain and Baldwin Roller Chain are used to transmit power in drilling rigs.

Rex Durobar Combination Chain is used in these bucket elevators handling crushed stone.

Economical Rex Steel Detachable Chain is used in this corn sheller.

1000 Chains

to cut costs, save space, increase machine

Did you know there were that many sizes and types of chains? There are . . . in the complete Chain Belt Line . . . and it's an important fact to know if you're interested in designing for lower costs, both first and operating!

No one type of chain is equally efficient for all power transmission, timing or conveying functions. A finished steel roller chain is ideal for high speed power transmission, but a steel Chabelco Chain will deliver more where speeds are slow, operating conditions severe and economy important. Or, suppose the conditions involve corrosive or abrasive service. A Rex Cast Chain in either malleable iron or Rex Z-Metal is a better choice. Perhaps the problem in-

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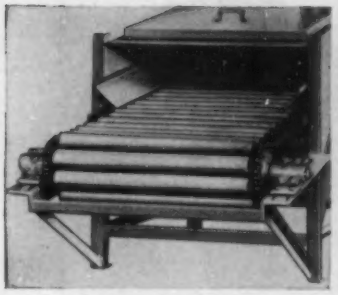


REX Pintle Chains are used with wooden carrier rolls in this Roller Scalder.

Baldwin-Rex Double Pitch Roller Chains drive the conveyors on a harvesting machine.

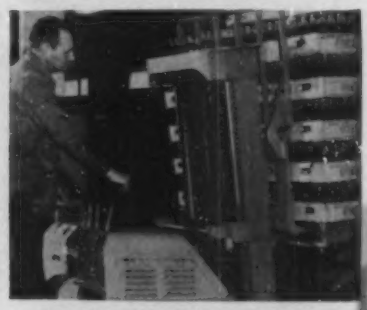
Rex Steel Chabelco Chains are used in this shovel and in many other types of construction machinery.

for 1001 Ways

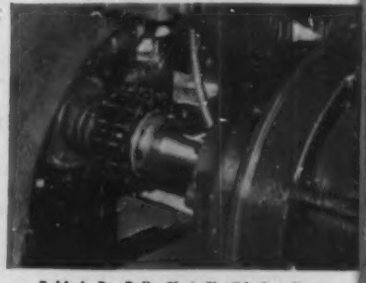
efficiency, improve product appearance!

volves the conveying of bottles, jars or cans. Rex Table Top Chain or Baldwin-Rex Plate Top Chain is the best solution here.

That's why it will pay dividends in lower first and operating costs if you carefully consider the matter of power transmission, timing or conveying in your designs. And, it will pay you to talk over your chain application problems with a Chain Belt Field Sales Engineer. Because he handles a complete line of chain, he can recommend, without prejudice, the exact chain for your needs. Call or write the Chain Belt Field Sales Office near you or, if you prefer, mail the coupon below.



Baldwin-Rex Roller Chains supply the right combination of high strength and light weight for this lift truck.



Baldwin-Rex Roller Chain Flexible Couplings provide true flexibility without backlash.

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- Rex Cast & Steel Detachable Chains
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- Rex H-Type Drive Chains
- Rex H-Type Conveyor Chains
- Rex Refuse & Log Haul Chains
- Rex Transfer Chains
- Rex Lay Bushed Chains
- Rex Combination Chains
- Rex Durobar Chains
- Rex Cast Roller Chains
- Rex Double-Flex Chains
- Rex Sugar Mill Chains
- Rex Chabelco Steel Chains
- Rex Offset Side Bar Roller Chains
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- Baldwin-Rex Cut Tooth Sprockets
- Baldwin-Rex Flexible Coupling and a complete line of chain attachments.

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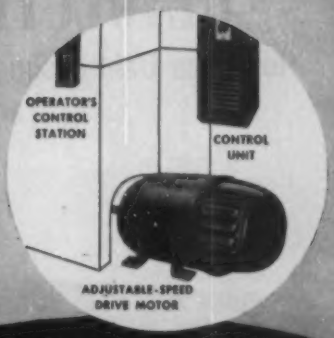

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The new low-cost Reliance V★S Drive (¾ to 2 hp.) performs all the functions of mechanical transmissions — electrically! Operating from A-c. circuits, it is the ideal choice for printing presses, paper winders and slitters, packaging machines, industrial food mixers, machine tools, conveyors and many other types of equipment. Write today for Bulletin D-2101 which gives further details.

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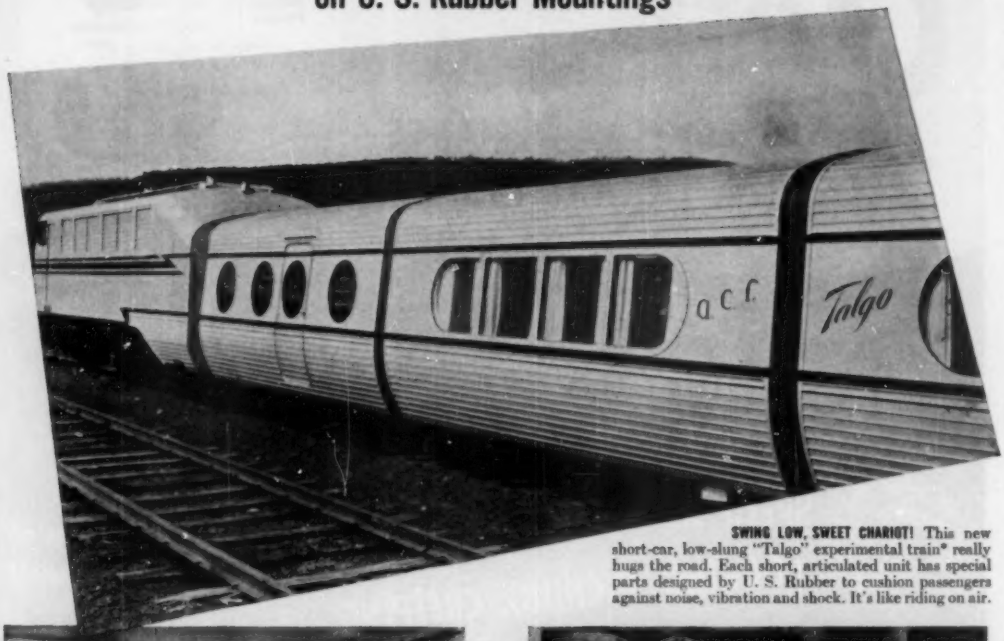

SWING LOW, SWEET CHARIOT! This new short-car, low-slung "Talgo" experimental train* really hugs the road. Each short, articulated unit has special parts designed by U. S. Rubber to cushion passengers against noise, vibration and shock. It's like riding on air.

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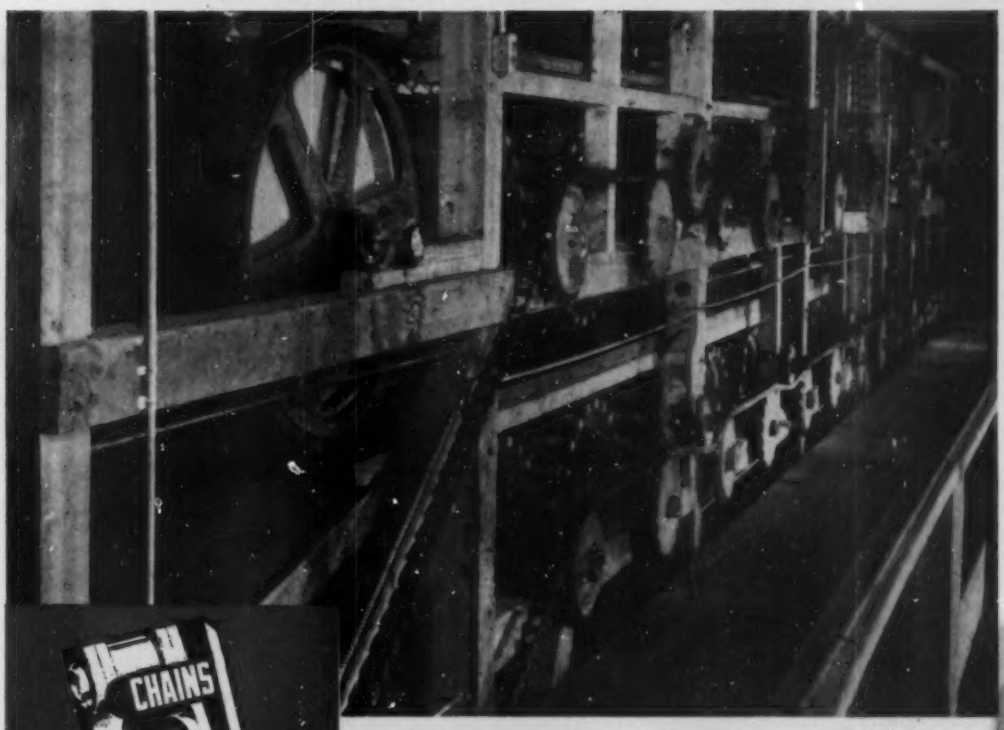

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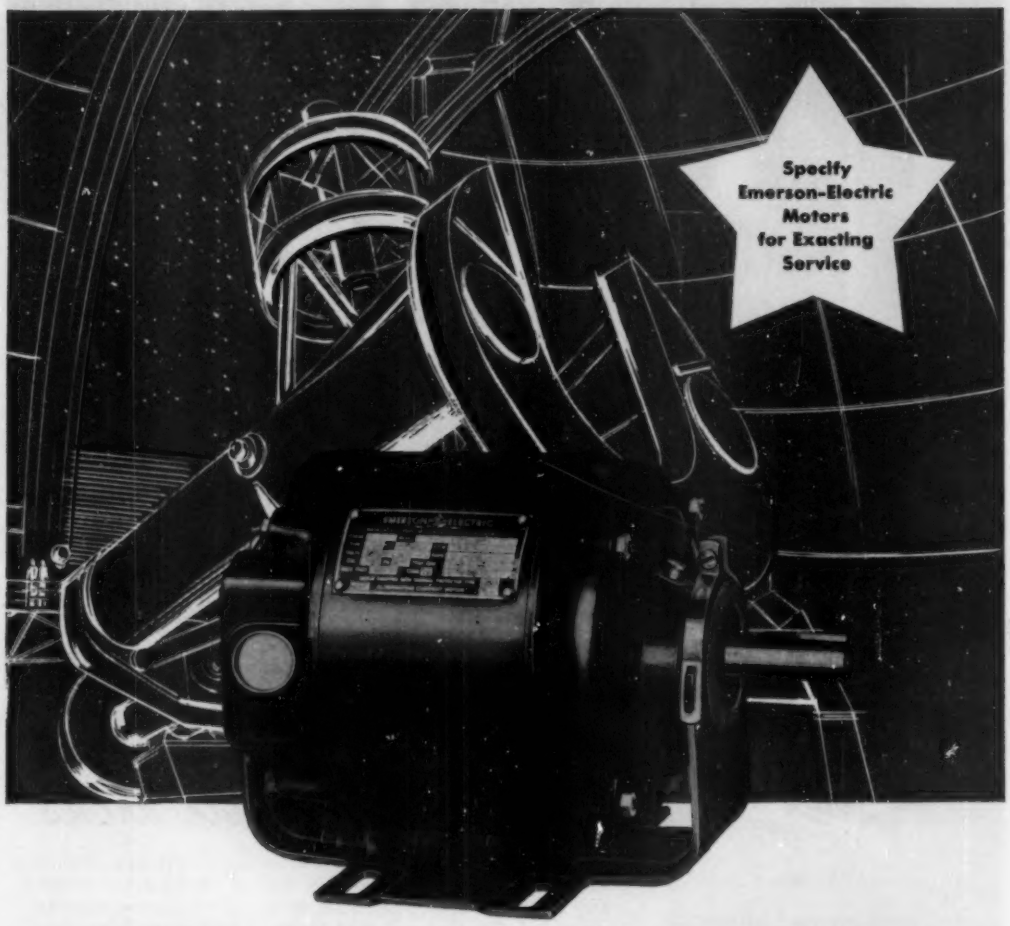

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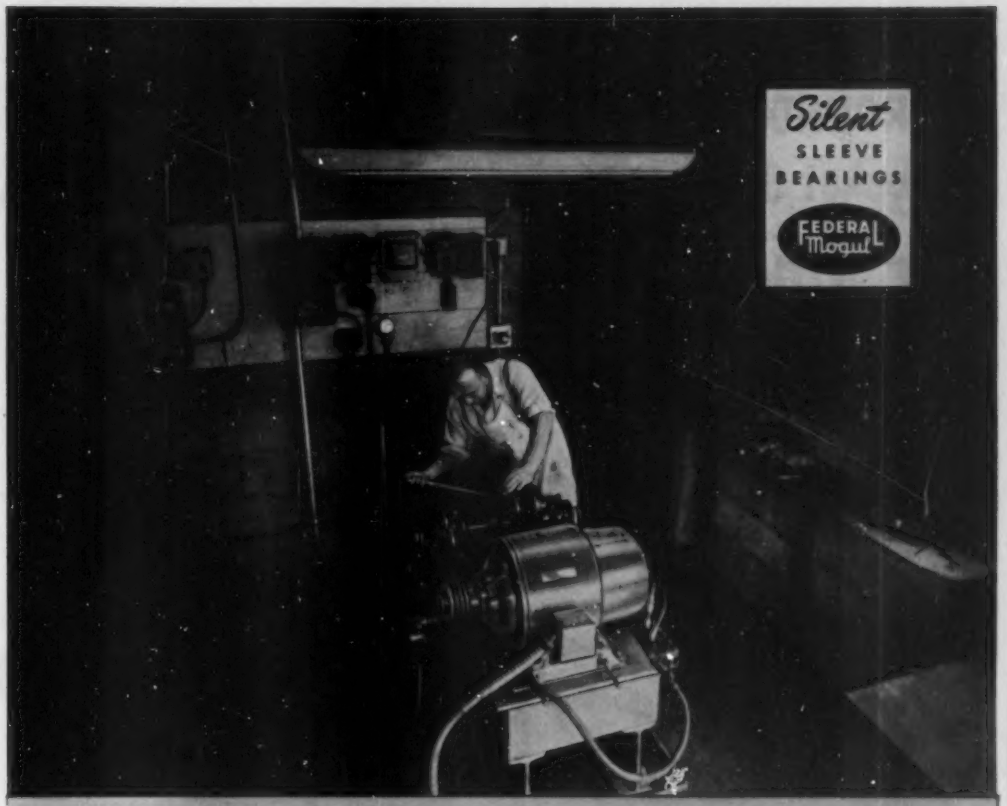

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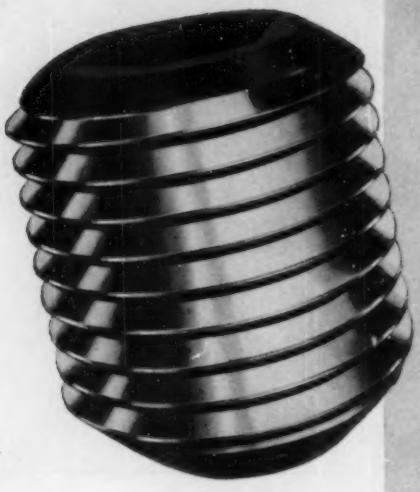

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Quick starting, they speed assembly work and improve production.

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Made from hardened stock, they have the smoothness of a true ground finish.

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Free from nicks, burrs and tool marks, they give you a dependable Class 3 Fit.

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Send for Samples. Feel the difference thread grinding makes. Check the uniform Class 3 Fit. Notice how much smoother (and easier starting) Parker-Kalon Socket Screws are, the way they "set up" to dependable security. Once you try 'em, you'll use them regularly—to speed your assembly work. Write for samples today. Parker-Kalon Corporation, 200 Varick St., New York 14, N. Y.

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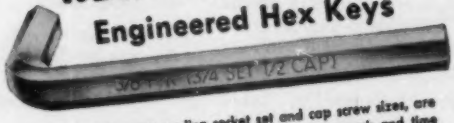
NEW... Size-marked Engineered Hex Keys



Key size, and corresponding socket set and cap screw sizes, are clearly stamped on arm of key. Eliminates guesswork and time wasted selecting the right key. The Size-Mark is especially useful in training new help.

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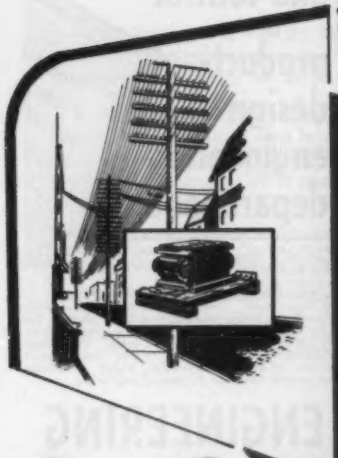

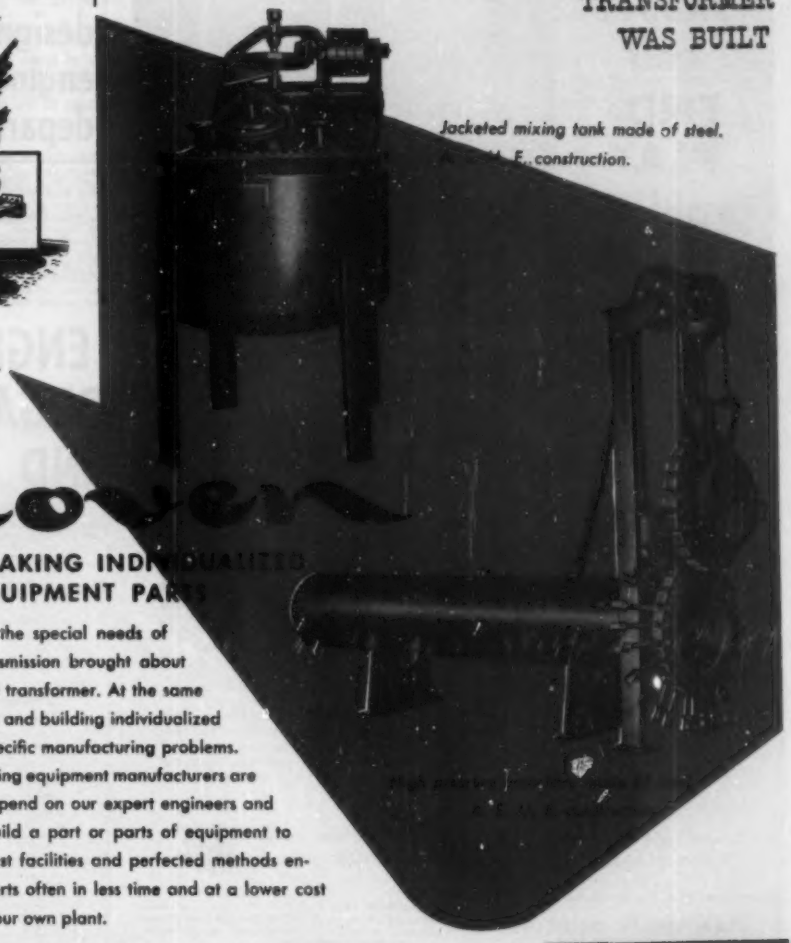

Jacketed mixing tank made of steel. ... construction.

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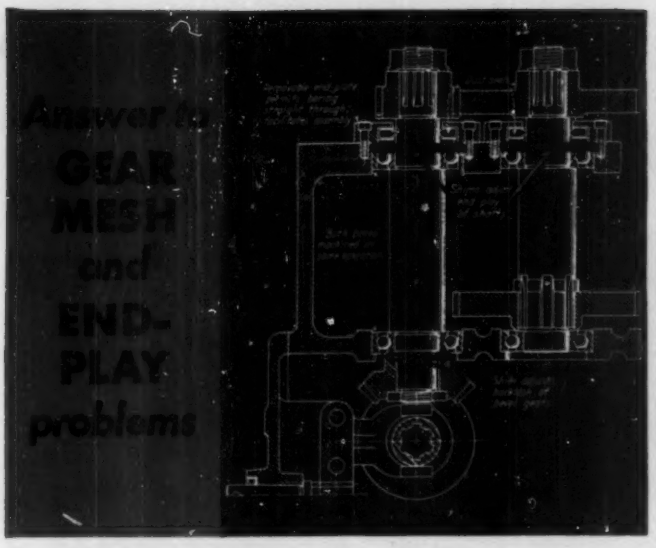
KOVEN FOR INDIVIDUALIZED EQUIPMENT PARTS SINCE 1881



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Laminated shims can stop the expensive process of assembly, testing, disassembly, machining a few thousandths, reassembly, retesting and so on for many costly hours.

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* ***LAMINUM*** (Reg. U. S. Pat. Off.) shims are solidly bonded units made up of .002 or .003 inch brass or steel laminations with a microscopic layer of metallic binder. Cut to your exact specifications.

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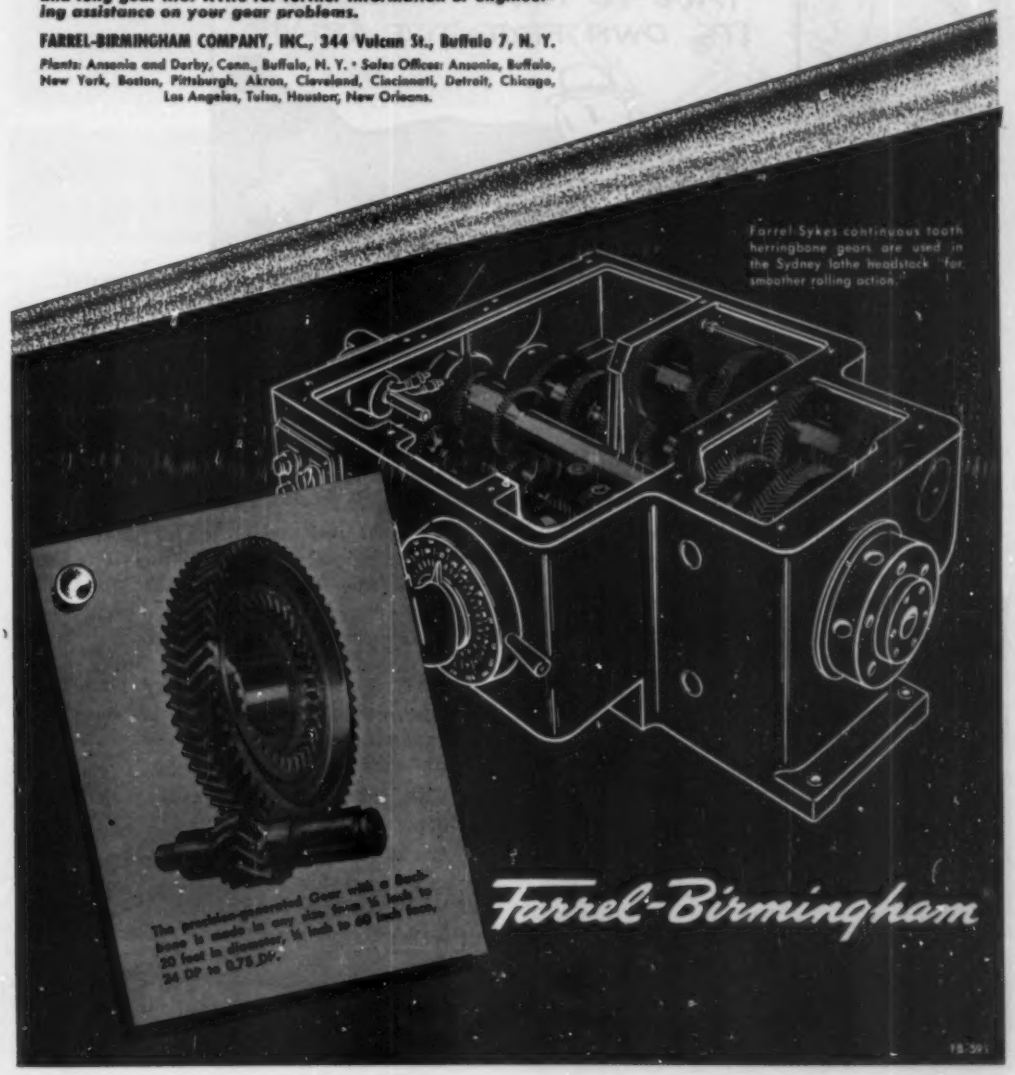
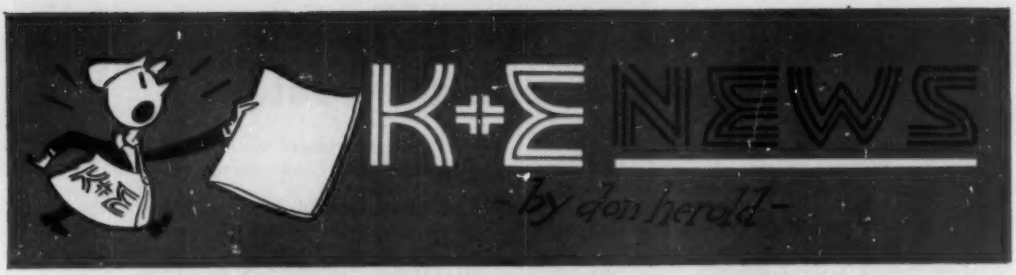

Farrel-Sykes continuous tooth herringbone gears are used in the Sydney lathe headstock for smoother rolling action.
The precision-generated Gear with a Backbone is made in any size from 14 inch to 20 feet in diameter, 14 inch to 60 inch face, 24 DP to 0.75 DP.
Farrel-Birmingham



the tape with the "inbuilt" permanent legibility

Here's the black-on-white steel tape that you might say is built with "hob nails". The name is WYTEFACE* "A".

It is made for a tough, rough-and-tumble, outdoor life. It is designed for dragging and for other forms of degradation which an engineer's tape must endure.

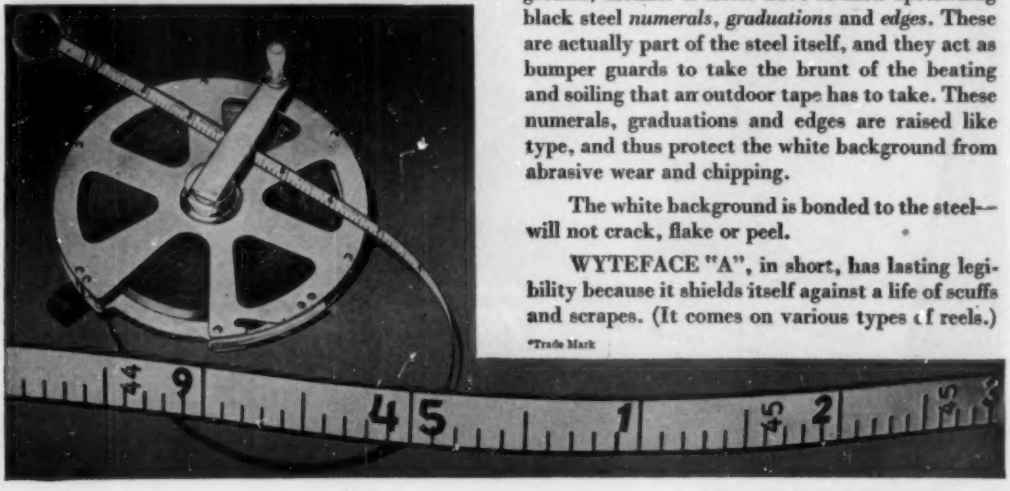
The explanation is:

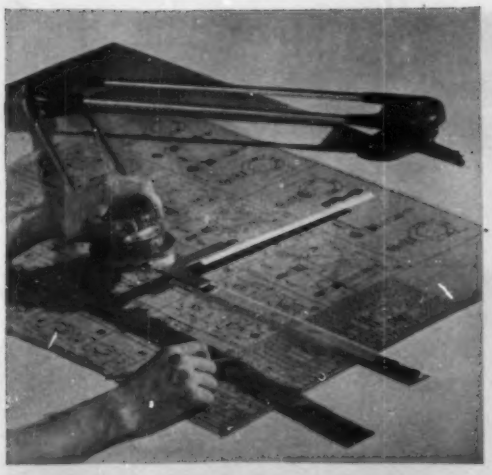
As a permanent and integral part of a basically strong steel tape which bears a lasting white background, Keuffel & Esser have formed upstanding black steel *numerals*, *graduations* and *edges*. These are actually part of the steel itself, and they act as bumper guards to take the brunt of the beating and soiling that an outdoor tape has to take. These numerals, graduations and edges are raised like type, and thus protect the white background from abrasive wear and chipping.

The white background is bonded to the steel—will not crack, flake or peel.

WYTEFACE "A", in short, has lasting legibility because it shields itself against a life of scuffs and scrapes. (It comes on various types of reels.)

*Trade Mark



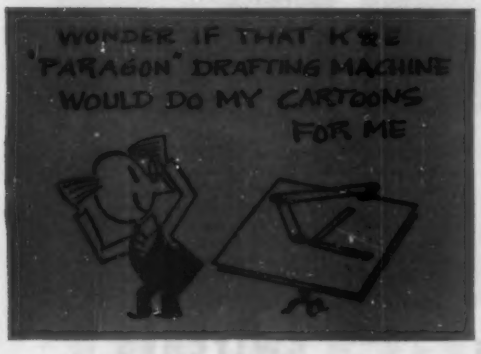


it's twice as fast as "human" drawing

You wouldn't try to be Rachmaninoff without a piano, or a Kreisler without a fiddle. Well, who would want to be a draftsman without a K&E PARAGON† DRAFTING MACHINE?

This miracle machine makes you a veritable orchestra leader at your drawing board. It combines T-squares, triangles, protractors and scales, all in one unit, controlled entirely by one hand.

You can move a rule all over the board, and the rule stays parallel to its original position. You can draw all lines to exact length. The lightest touch rotates the scales to any angle desired.



Permanent accuracy is assured, because the open center arm construction makes it practically impossible to disturb the factory-set band tension.

†Trade Mark ®

this wheee-eraser saves time and elbow grease

This K&E MOTORASER* makes old-fashioned hand erasing look horse and buggy. It reduces your erasing time to seconds.

Since it depends on speed rather than pressure, the MOTORASER does not wear holes in paper. It's as accurate as a pencil point, yet will clean large areas in a jiffy.

It's handy in the hand—a 3 inch palm full with a finger-tip switch—only 6 oz. Uses AC juice —60 cycle 110 volt AC—or DC with an inexpensive adapter. A sturdy little feller, too.

*Trade Mark

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One of the assembly lines in our Relay Department

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RELAYS SWITCHES

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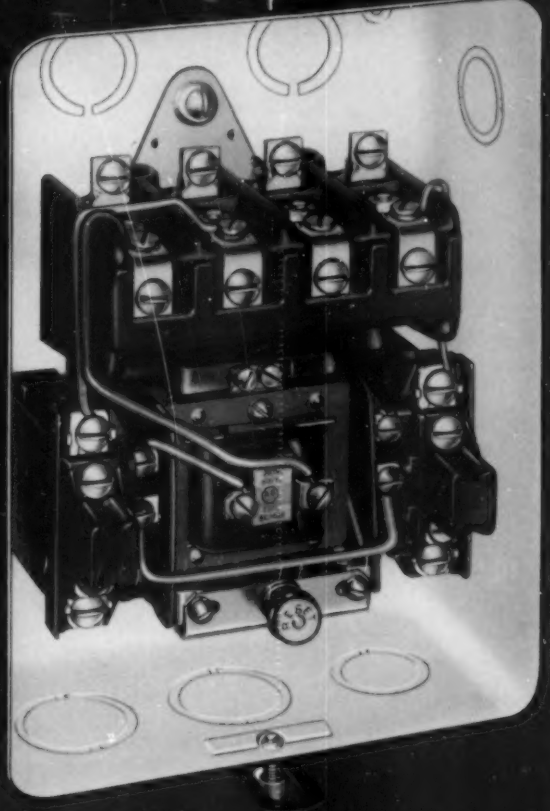
Imitation is the sincerest of flattery

Charles C. Colton



WHY...

do so many starters look like

Allen-Bradley

Solenoid Starter

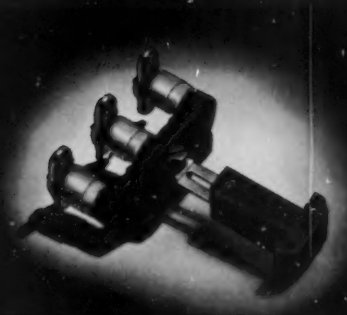
ALLEN-BRADLEY

THE MOST IMITATED MOTOR STARTER

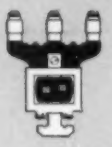
QUALITY

A-B Quality

SIMPLICITY—



1 **To eliminate trouble-making pins, pivots, etc., you need *Simple Solenoid Action***



The insulating cross bar, carrying the moving contacts of the Allen-Bradley starter, are mounted right on the solenoid plunger. No linkages . . . no pivots or pins.

2 **To get small size and to permit close mounting, you need *Enclosed Arc Hoods***

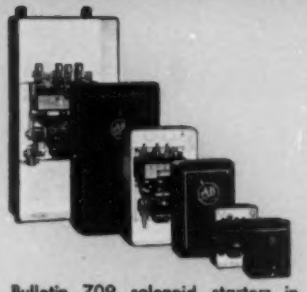
The solenoid construction, with its straight up and down motion and enclosed contacts, is extremely compact. Units can be mounted close together on panels or in machine bases.

3 **To eliminate contact maintenance, you need *Silver Alloy Contacts***

The patented silver alloy contacts, pioneered by Allen-Bradley on Bulletin 709 solenoid starters, have made contact maintenance, such as filing, cleaning, and dressing, unnecessary.

4 **To make panel mounting easy, you need *Unit Construction***

Allen-Bradley also pioneered the self-insulated starter mounted on a metal back plate. Bulletin 709 solenoid starters can be grouped closely on control panels of all types.



Bulletin 709 solenoid starters in Sizes 0 to 5, inclusive, for motors up to 100 hp, 220 v; 200 hp, 440-550-600 v.

Bulletin 709 solenoid starters, in Sizes 6 and 7, for motors up to 300 hp, 220 v; 600 hp, 440-550-600 v.

Ample space is provided for the heavy conductors to line and motor terminals. Allen-Bradley starters are available in enclosures for every service . . . indoor or outdoor.

ALLEN-BRADLEY

SOLENOID MOTOR CONTROL

QUALITY

A-B "Quality"

3508

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ANODES

HELP YOUR PLATING PROBLEM

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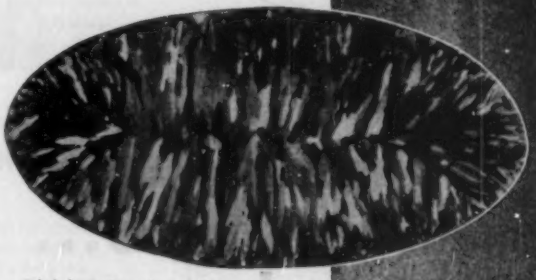

"Seycast"

A HANDY LIST OF SEYMOUR ANODES

99%+ *Rolled Depolarized* — A very fine, homogeneous, even-grained virtually pure nickel anode. Corrodes in hot or cold solutions with minimum metallic loss. Forms practically no sludge. Especially suitable for baths having a pH above 4.5 electrometric.

99%+ *Rolled Carbon* — A rolled anode of high efficiency for low pH hot Watts baths not above 4.5 electrometric. Corrodes smoothly with a minimum of loose nickel.

99%+ *Cast Carbon* — A pure nickel anode with carbon content adjusted for smooth, uniform corrosion without special controls. Available, however, with carbon content to meet any specifications. Adaptable for general shop work using hot or cold baths.

95-97% *Sand Cast* — Corrodes readily in solutions low in nickel or weak in salts — therefore suitable for cold, high pH, low current density plating solutions. Uniform corrosion throughout the life of this anode is obtained by an even distribution of the carbon content. A 90-92% Sand Cast Seymour Nickel Anode is also available.

"Seycast" — An improved type of 99%+ cast anode of very high efficiency designed primarily for Bright Nickel baths, but works perfectly in any hot Watts bath having a pH of 4.5 electrometric or lower. Corrodes evenly with practically no loose nickel formation, due to long, interlocking grains radiating from a common center. Especially suitable for high current densities.

Bright Nickel — A hot organic type process free from promoter metal, stable and easily controlled. Produces brilliant deposits from a standard hot nickel bath without the usual colorizing or buffing. Excellent throwing power, wide operating conditions. Free from wetting out agents.

OTHER ANODES — Seymour Anodes in all shapes to meet rigid specifications are also available in copper, brass, bronze and zinc. The copper used is electrolytic. The zinc is always the best grade obtainable.

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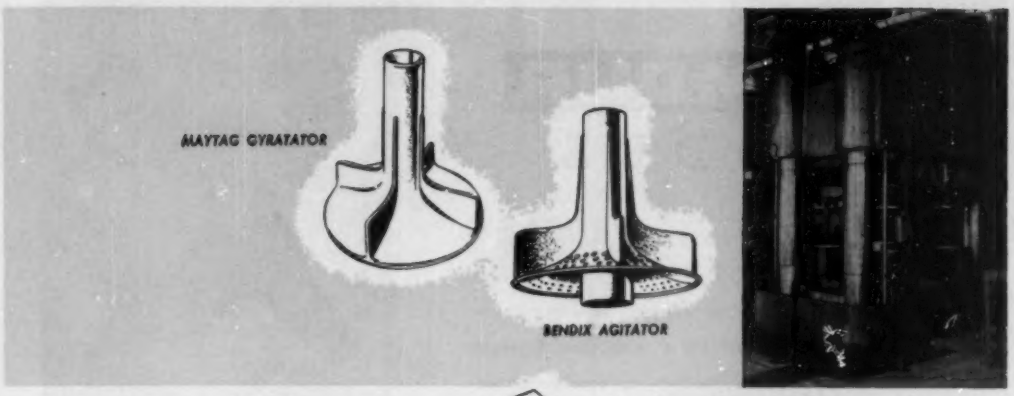

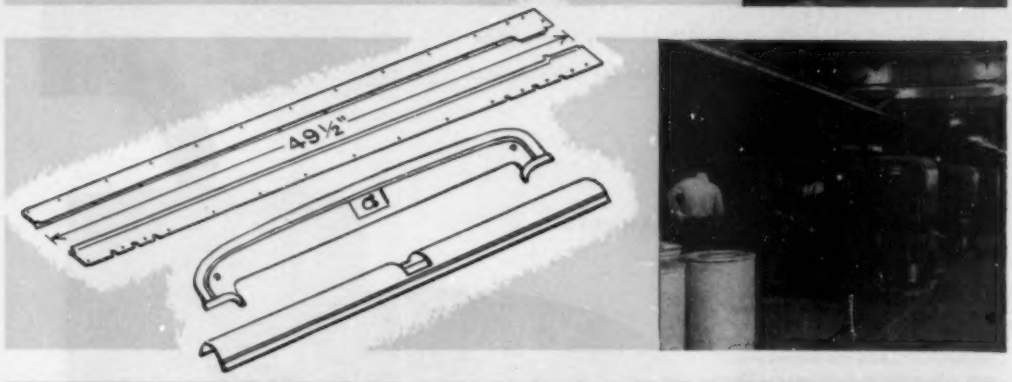

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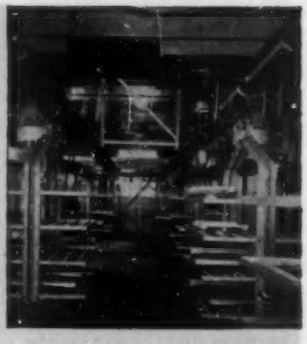

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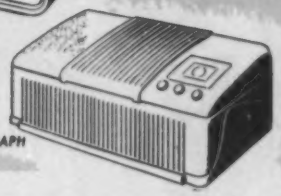

PHILCO RADIO-PHONOGRAPH

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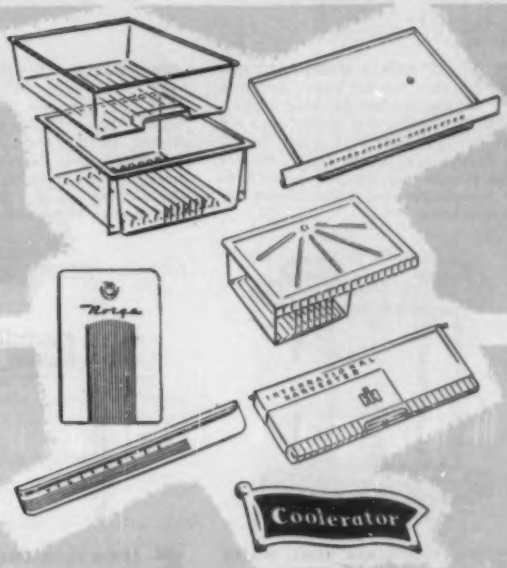
The economy of molding high-impact polystyrene in large pieces has proved itself at General American. The Frigidaire breaker strip shown here is 49½ inches long. The other parts illustrated have given important savings to such famous manufacturers as Servel, International Harvester, Norge, Crosley, Westinghouse, Frigidaire, Kelvinator, Admiral and Coolerator. Close tolerances in these pieces is essential—and a specialty at General American. Injection presses from 2 to 48 oz. are available.



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To back up your production line, General American offers you high speed, completely mechanized Logoquant treating and painting of polystyrene. General American has reached an exceptionally high mechanical efficiency in painting and assembly.

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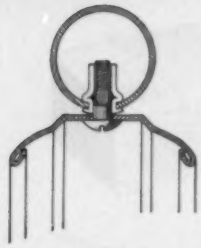
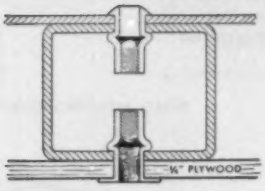
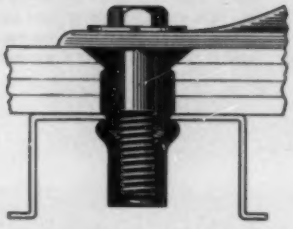
RIVNUTS solve tough fastening problems



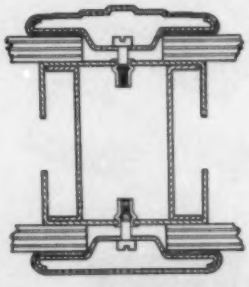
1 TO ATTACH A MUDGUARD to a bicycle's tubular frame, designers used a standard flat-head Rivnut. The correct radius was ground into the anvil of the heading tool, which curved the Rivnut head at the same time the bulge was formed. The still-intact Rivnut threads provided a firm anchor for the attachment screw.



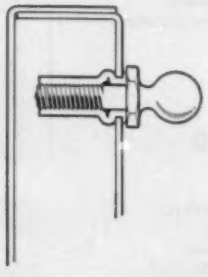
2 RIVNUT AT BOTTOM (above) fastens plywood walls to tubular steel sections in trailer. Large washer head and bulge in shank prevent Rivnut pulling through plywood or vibrating loose. Rivnut at top rivets steel sheet to opposite side of section. *One man* can install a Rivnut from one side of work *in two seconds*.



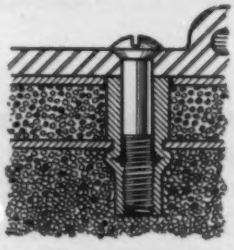
3 BUS DESIGNERS used Rivnuts—*the only one-piece blind rivet with threads*—to fasten seats to plywood floor board. Heading tool upset Rivnut, forming bulge under floor board. Splines on Rivnut shank took care of torque. At least 6 Rivnut threads remained clean to grip attachment screw. Many man-hours were saved in assembly.



4 THE PORCELAIN STEEL WALLS of this pre-fabricated building are securely fastened, yet easily removable for moving or repairs—thanks to Rivnuts. Installation is made by one man from one side of studding. Rivnuts require only very small hole, provide wide bearing surface. Cap screws threaded into Rivnuts attach walls.



5 THREE PROBLEMS WERE SOLVED by Rivnuts in this kitchen cabinet door. (1) Rivnut was installed from one side only, (2) It furnished at least 6 clean threads for attaching knob, and (3) It was installed *after* enameling without marring the finish. Rivnuts improved product quality, saved many man-hours on this job.



6 WALK-IN REFRIGERATOR uses special-type Rivnuts to attach hinges to door made of steel sheets and sponge insulation. Spacer head allows upsetting of Rivnuts deep in door. Rivnuts form compression fit which—combined with closed Rivnut end—provides positive sealing. Clean threads take hinge attachment screws.

B.F.Goodrich

RIVNUTS

The only one-piece blind rivet with threads

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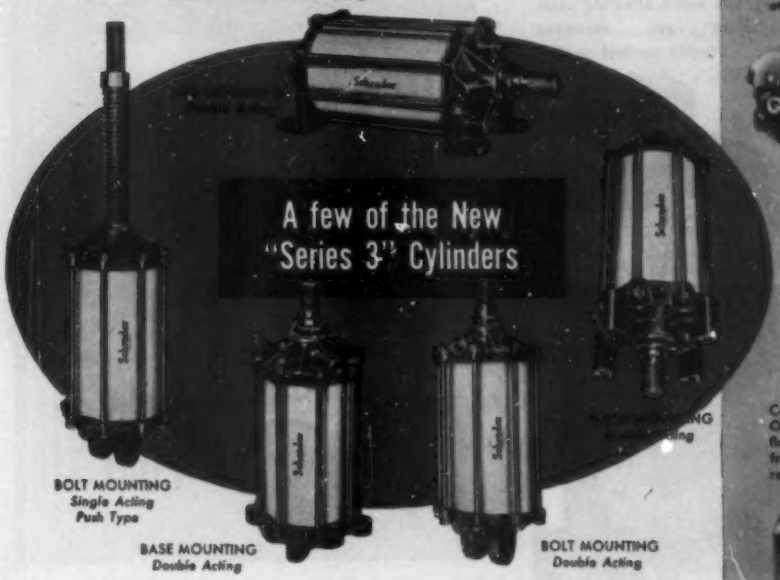
Have a fastening problem? Get the help of Rivnut engineers. Ask also for free demonstrator that shows with motion how Rivnuts work. Explains construction. Gives applications. Write to The B. F. Goodrich Company, Dept. PE-50, Akron, Ohio.

Make hard work EASY with BRUTE POWER from these BRAWNY NEW AIR CYLINDERS



What's your problem? Operating press brakes, clutches, doors, clamping work, lifting or lowering, pushing or pulling heavy loads?

Investigate the time-saving, work-saving advantages of the new Schrader Air Cylinders. See how they do hard jobs faster, safer, better.

See what Schrader has done to make this new series of air cylinders tops for ruggedness, for fast cycle operation, and ease of mounting. See how interchangeability of the parts cuts down maintenance.

WIDE RANGE OF SIZES AND TYPES

These new Schrader Air Cylinders come in a range of sizes and types broad enough to satisfy anyone—single acting (push or pull), double acting (with or without adjustable cushion), in a variety of mountings, and in cylinder diameters from 1" to 8" bore, and in any stroke.

NEW BANTAM-SIZE AIR CLAMPS—Small, powerful light-weight. Base or leg mounting. Six models in each type. Strokes 1" to 2", cylinder diameters 1", 2¼" and 3". Low in cost.

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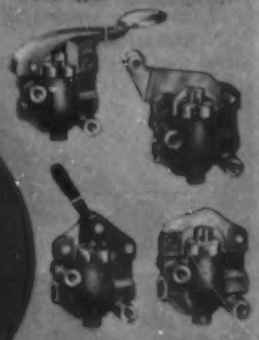
These are 3-way with roller lever, solid angle lever, hand lever, and hand lockdown lever. Some valves available in 2-way. The complete Schrader catalog shows many other types.



New 4-Way Valve

Completely new in design. Operates at the touch of a finger. Diaphragm seat. Large free air capacity. Ports arranged for hidden piping.

Improved Design Pilot Valve

One of many types of Schrader Pilot Valves, 2 or 3-way, with or without timer.

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Blow Guns, Ejection Sets, Filters, Gauges, Hose, Hose Fittings, Hose Reels, Lubricators, Machine Control Sets, Pressure Regulators, Quick Acting Couplers, Rotating Pressure Joints, Uniflare Fittings, Hydraulic Gauges.

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Please send me information and free literature about the products I have checked in the squares at the right.

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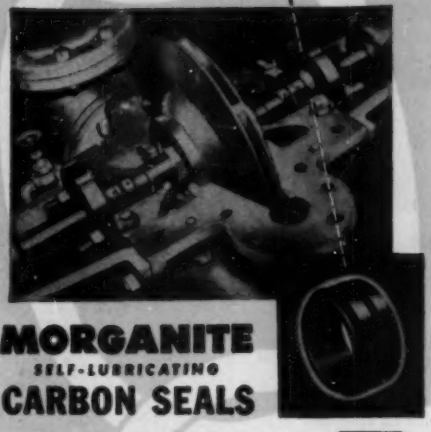
PROBLEM: To produce a mechanical seal capable of withstanding corrosive chemicals . . . grit . . . high shaft speeds . . . highly volatile fluids . . . under extreme pressures.

SOLUTION: Morganite self-lubricating seals . . . immune to chemical attack . . . grit . . . abrasives . . . mechanically strong . . . provide perfect sealing free from warping or gumming.

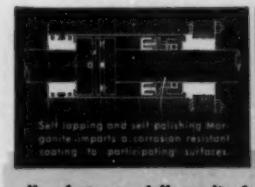


MORGANITE
SELF-LUBRICATING
CARBON SEALS

In continuous service where pressures and shaft speeds are extremely high, Morganite Seals have proven highly efficient. They are recommended for use in pumps, agitators, mixers and similar equipment handling liquids including corrosives. Where maintenance is difficult due to inaccessibility, the self-lubricating feature is especially valuable. Costly repairs and lengthly shut downs due to seal failures are eliminated.

Additional data on Morganite will be found in Sweet's File for Product Designers. For competent engineering help on specific problems consult a Morganite sales engineer. There is no obligation.

REGISTERED TRADE MARK **Morganite** INCORPORATED
LONG ISLAND CITY 1, NEW YORK



Self lapping and self polishing Morganite imparts a corrosion resistant coating to participating surfaces.

Seal units incorporating Morganite are available with self-adjusting and wear-compensating features.

Manufacturers of Morganite Carbon Brushes for all motor and generator applications, and Morganite Carbon Piles.

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The combinations of styles, types, mountings, ranges and functions of Marsh Gauges are almost endless; but they all have one trait in common: Each is best for the service for which it is recommended. Write today for the new Marsh Catalog covering the broad Marsh line. Let us prove that Marsh is the gauge for your product, whether you need a few or thousands.

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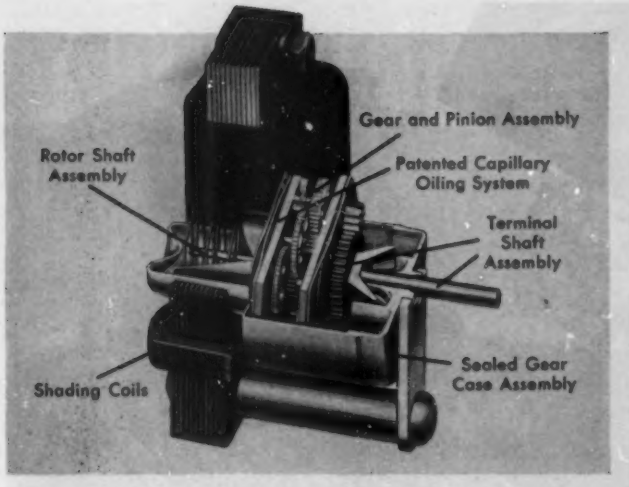


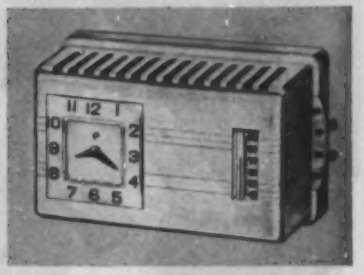
Unique Oiling System Prolongs Timing Accuracy

Capillary action in the spaces between each bearing and capillary plate of Telechron Timing Motors draws a specially formulated oil from the reservoir at the bottom of the sealed gear case. This keeps bearings and pivot surfaces constantly covered with a thin coating of oil. Oil creepage along the shafts, pinions and gears maintains complete, continuous lubrication. Brass terminal gear baffles meter the right amount of oil to the terminal shaft bearing . . . cutting down bearing wear and making the sealed-in oil supply last for years.

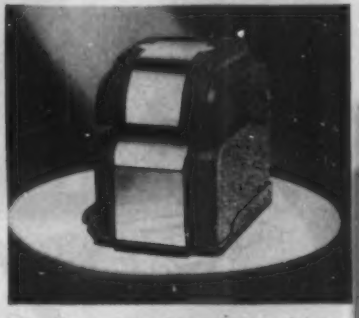
This oiling system is just one of many reasons why *all Telechron Timing Motors are instantly, constantly synchronous* . . . and why designers concerned with split-second timing or precise control of lightweight moving parts invariably specify Telechron motors.

If accurate timing enters into your product design, talk things over with a Telechron Application Engineer. Backed up by the experience that makes all electric timing possible (virtually all frequency-controlling master clocks in power stations are made by Telechron), he can probably show you how to save time and money by fitting a standard Telechron motor into your product. In the meanwhile, get complete data by mailing the coupon below. Telechron Inc. A General Electric Affiliate.

Telechron Type B Synchronous Motor. For switches, recording-controlling mechanisms and other medium duty controlling purposes. Other models available with lower or higher torques for light or heavy duty applications.



Controlling the timing of heat regulators is typical of the jobs well done by Telechron Type H3 light duty motors.



Most time-stamps and recorders owe their accurate timing to Telechron Type B motors because such applications demand a motor that is instantly, constantly synchronous.

Telechron®

ALL TELECHRON TIMING MOTORS ARE INSTANTLY . . . CONSTANTLY SYNCHRONOUS

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Please send me information on sizes and types of Telechron Synchronous Motors. My possible application is:

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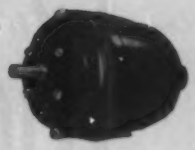
We'll be glad to send you literature on these new motors. And, if you would like to have R & M sit in on a discussion of *powering improvements*—that's yours for the asking, too. Address Robbins & Myers, Inc., Motor Div., Dept. P-50, Springfield 99, Ohio.



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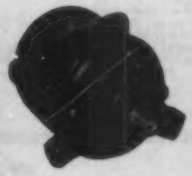

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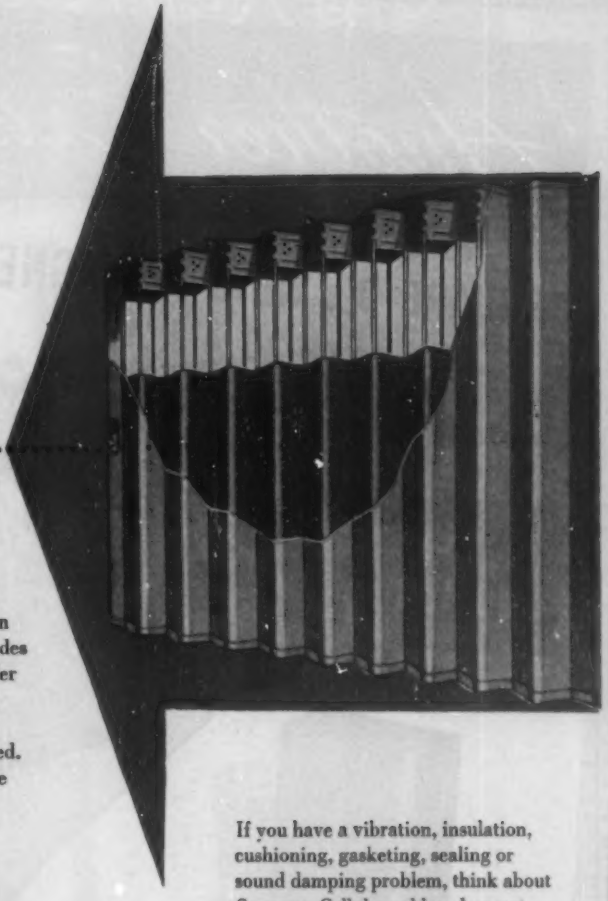
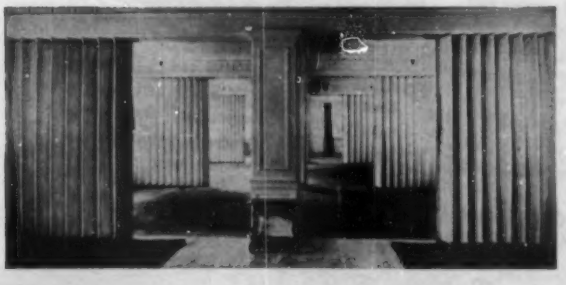


New Castle Products make the Modernfold accordion-like partition and closure which temporarily divides large rooms into two or more smaller ones. A sound retarding lining for installation in schoolrooms, offices and hotel banquet rooms was needed. In addition to deadening sound, the lining had to be flexible, durable, lightweight, small in bulk, free of dust and dirt, and economical. Spongex cellular rubber, in sheet form, answered their every need.



If you have a vibration, insulation, cushioning, gasketing, sealing or sound damping problem, think about *Spongex*. Cellular rubber does not become a "product" until you make it one in *your* application. We welcome new problems.

Technical Bulletin on Sponge Rubber available upon request.

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helps products to sell like "hot cakes"

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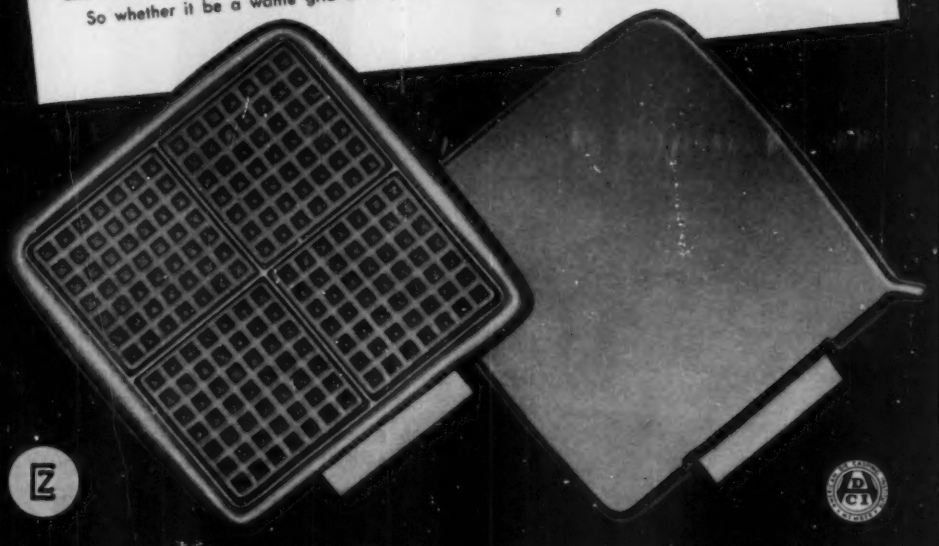
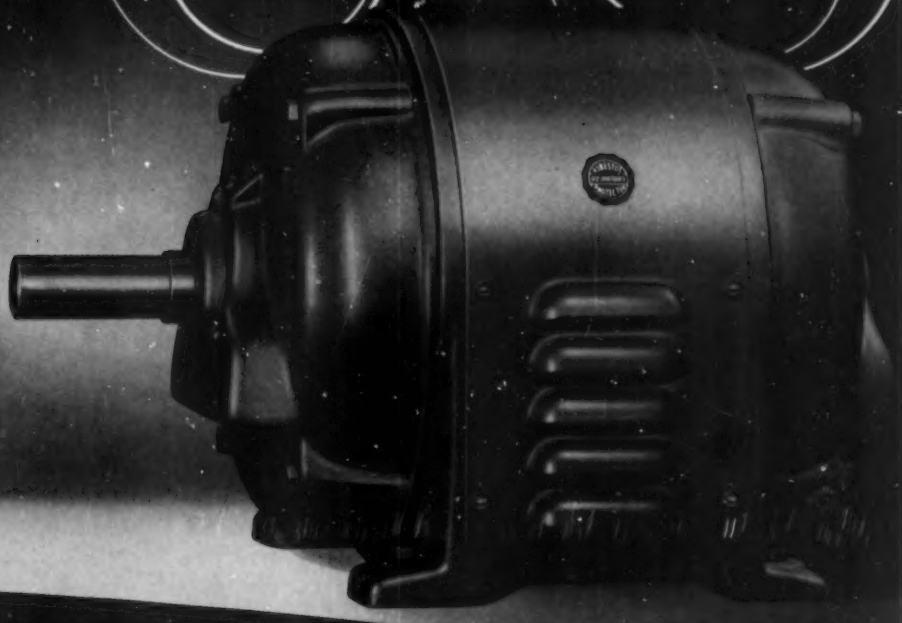


UNICLOSED MOTOR



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US MOTORS

(See next page)

1

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With Lubriflush

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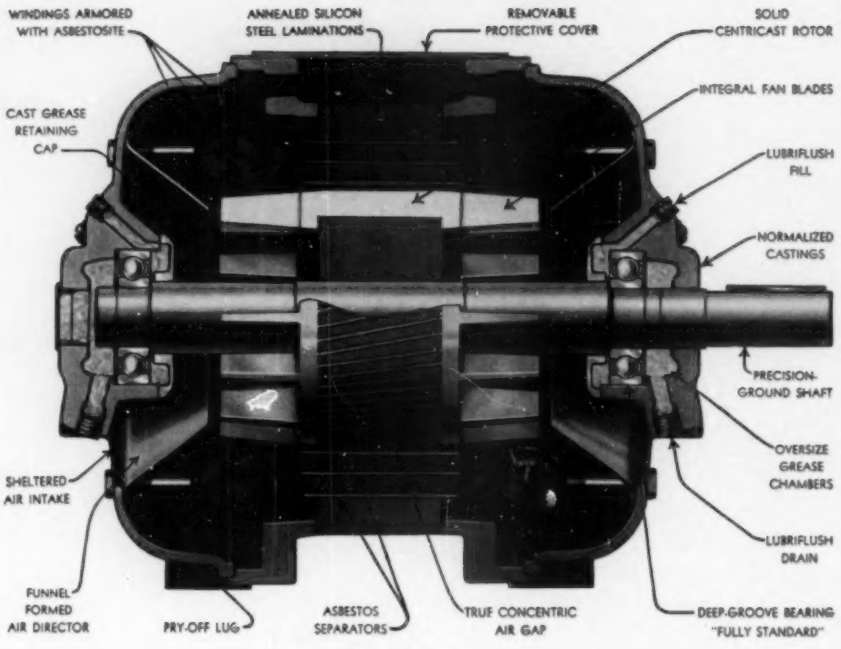

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The Uniclosed is no ordinary motor. It combines external protection with interior perfection. The vital operating parts are armored against damage from moisture, falling debris, dust and dirt. The Uniclosed is suitable for many conditions ordinarily requiring more expensive splash-proof or enclosed designs. Asbestos-protected windings guard against carbonization. Lubriflush lubrication insures longest life of bearings which are *self-lubricated* for normal life. Normalization of all castings insures permanent bearing alignment. Dual cyclone ventilation insures a cool running motor in high atmospheric temperatures. The rotor is centricast. The steel laminations are annealed to prevent excessive electrical loss.

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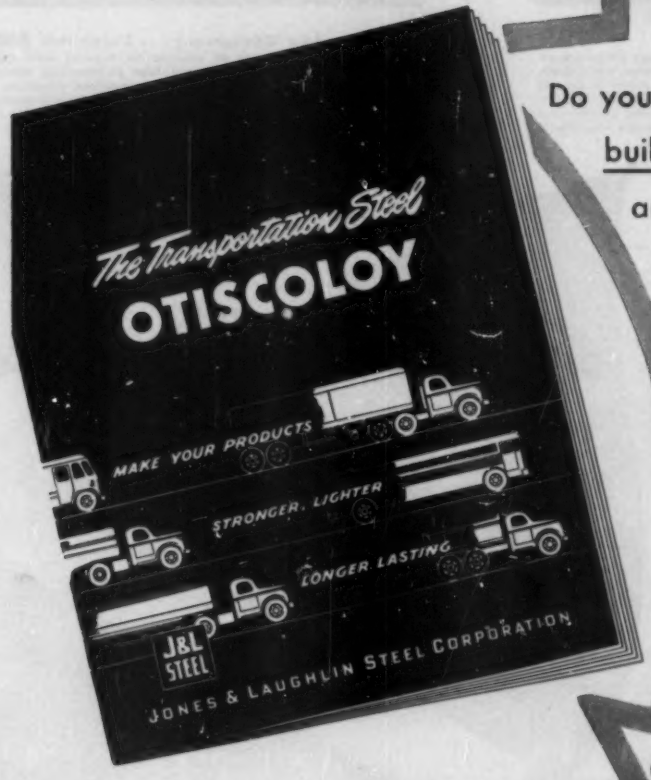

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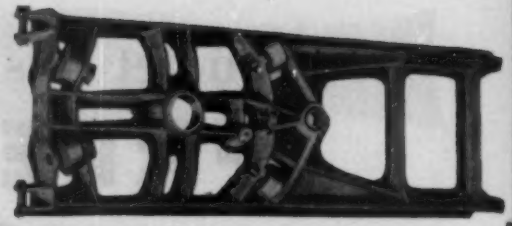
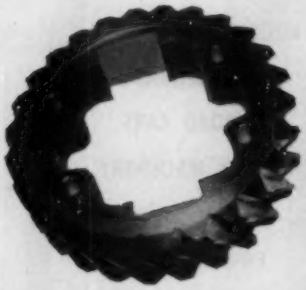
Rolling Mill . . . Screw-down Nuts — Ampco alloys are selected for their high resistance to terrific pressures and impact. Rolling mill pressures are transferred through the screw to the nut threads. In cases such as a blooming mill, this pressure is applied with impact — increasing from zero to several million pounds in a fraction of a second. That's why they need the tough strength of centrifugally cast Ampco aluminum bronze.

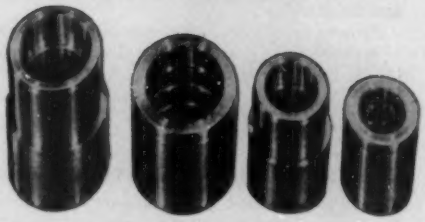


Earth-moving Equipment . . . Excavator Roller Bushings — Ampco Grade 16 selected for unusual wear resistance, excellent bearing qualities and high load-bearing strength. Turntable roller bushings must carry the tremendous weight of the cab, boom, and load. The turning is slow but eccentric because of the cantilever action of the boom and load. Ampco bronze alloys also used for gears, plates, cams, sleeves, and many other important excavator parts.



Garden Tractors . . . Worm Gears — Ampcoloy K-123 aluminum bronze selected for high strength and wear resistance, high impact and fatigue values. Reduced replacements to a mere 1/10 of the previous average. This outstanding saving is typical, accounts for the specification of Ampco aluminum bronzes for a wide variety of gears—from tiny fishing-reel gears to giant 1-ton gears for rolling mills.

Forging Machinery Upsetter Slides — Ampco Grades 18 and 20 selected by one manufacturer to replace hardened steel because they combine excellent bearing qualities with the necessary strength to withstand a 40,000 psi load. In two and a half years of service they showed little signs of wear. The same high physical properties make these alloys ideally suited for such applications as wear strips and wear plates.



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1. High tensile strength
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3. High impact and fatigue values
4. Excellent bearing qualities
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Long-wearing Ampco bronze alloys give you longer and better service — reduce down-time losses — and cut maintenance and replacement to a money-saving low.

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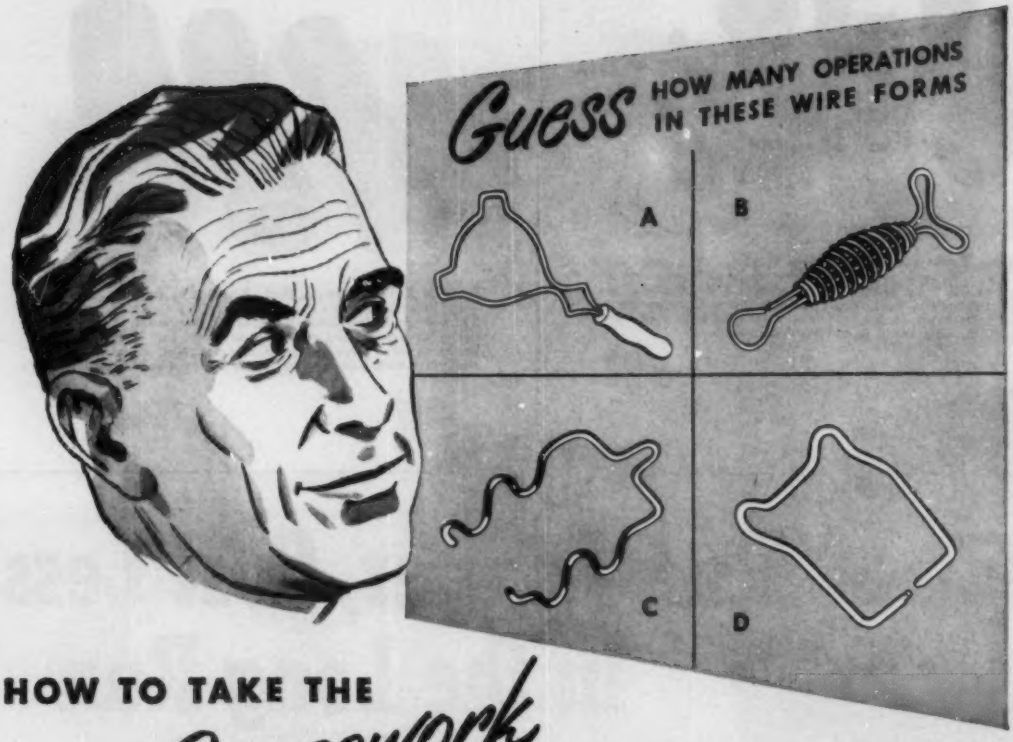

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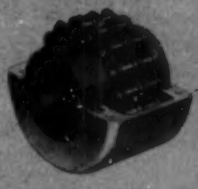

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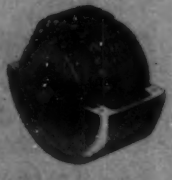

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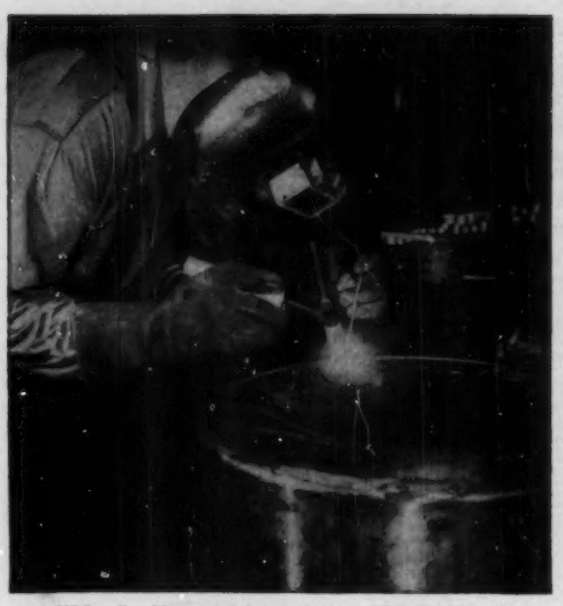

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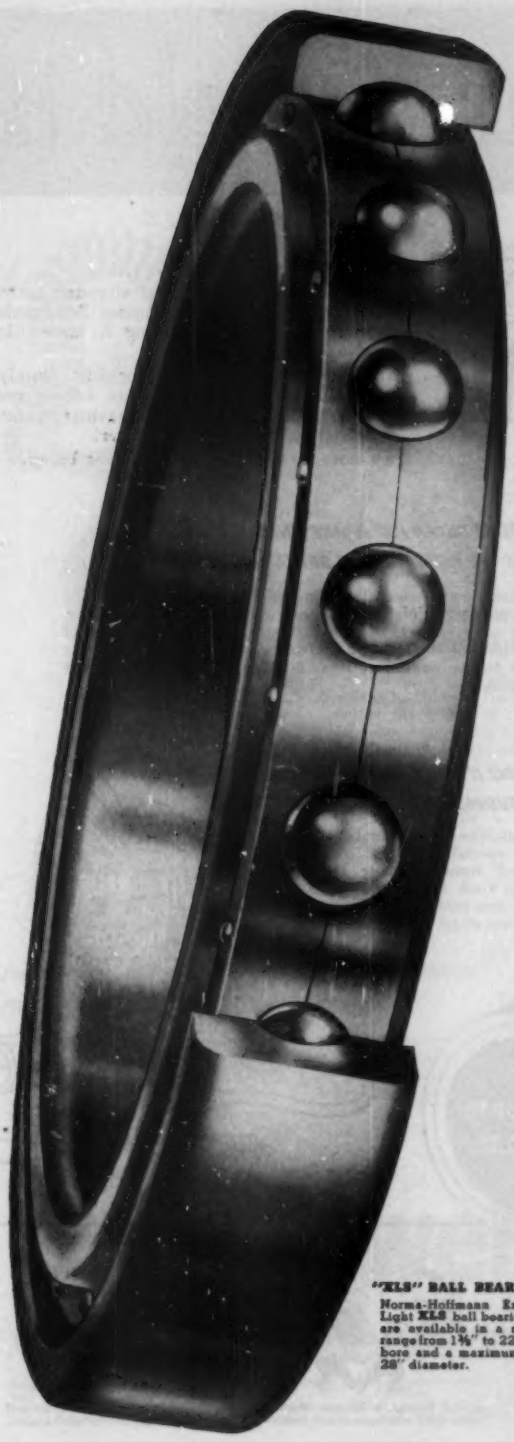

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From fabrication to finished product, Bundyweld gives advantages no other tubing can promise, often including major savings in cost. Sweet music to *any* manufacturer!

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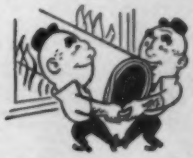
First, a single strip of basic metal, coated with a bonding metal, is . . .

rolled twice around into a tube of uniform thickness, then . . .



passed through a furnace. Bonding metal fuses with basic metal, presto—

Bundyweld . . . double-walled and brazed through 360° of wall contact.

the better tubing

MACHINE IT OR BEND IT, SWAGE IT OR FLARE IT;
FOR SMOOTH, EASY HANDLING YOU JUST CAN'T COMPARE IT!

With all its sturdiness, Bundyweld is easy to cut, machine, form or join. It bends more readily and takes more bending without collapsing or weakening structurally. Your tip-off to faster, smoother fabrication and lowered costs of tubular frames, refrigerant lines, beer coils, radiant heating systems, or a product you may be designing that happens to need a *better* tubing.

NO LEAKS UNDER STRESS IN YOUR LINES OR YOUR COILS;
BUNDYWELD'S PERFECT FOR BASES AND OILS.

High resistance to pressure your big must? Bundyweld is still your tubing! Halogen vapor leak detector tests, accurate for 1/100 of an ounce leak *per year*, give honors to Bundyweld for leakproof performance. It's double-walled and brazed through 360° of wall contact. Virtually never a chance of a leak!

SO, make it a point to find out today
How *your* use of Bundyweld really can pay.
Be it nickel or steel or Monel, you will find
No other tubing so soundly designed.

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FOR FREEDOM FROM SCALING AND OTHER DEFECTS.

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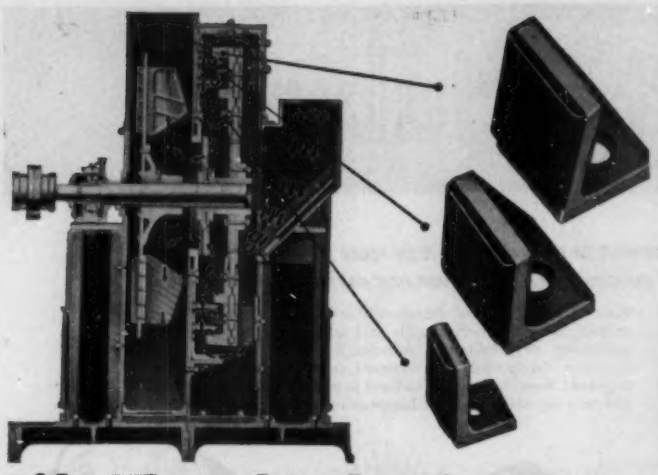
Bundyweld® Tubing

DOUBLE-WALLED FROM A SINGLE STRIP

Bundy Tubing Distributors and Representatives: Cambridge 42, Mass.: Austin-Hastings Co., Inc., 226 Binney St. • Chattanooga 2, Tenn.: Painter-Doubles Co., 823-824 Chattanooga Bank Bldg. • Chicago 32, Ill.: Lapham-Hickey Co., 3333 W. 47th Place • Elizabeth, New Jersey: A. B. Murray Co., Inc., Post Office Box 476 • Philadelphia 3, Penna.: Reton & Co., 404 Architects Bldg. • San Francisco 10, Calif.: Pacific Metals Co., Ltd., 3100 19th St. • Seattle 4, Wash.: Eagle Metals Co., 3628 E. Marginal Way Toronto 5, Ontario, Canada: Alloy Metal Sales, Ltd., 881 Bay St. • Bundyweld nickel and Monel tubing is sold by distributors of nickel and nickel alloys in principal cities.



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. . . and they're still going strong!

STEEL couldn't stand the grind when it came to pulverizing "soft" coal. When an industrial stoker manufacturer used steel "pegs" on rotary coal pulverizers, they had to be replaced after handling only 3,500 tons.

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11. Low electrical conductivity
12. Non-magnetic (if desired)

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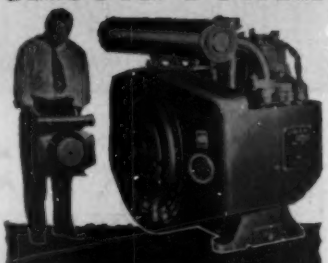
CARBOLOY® CEMENTED CARBIDE **HARD METAL**

The Versatile Metal of Industry

Lightweight

SMOOTH POWER



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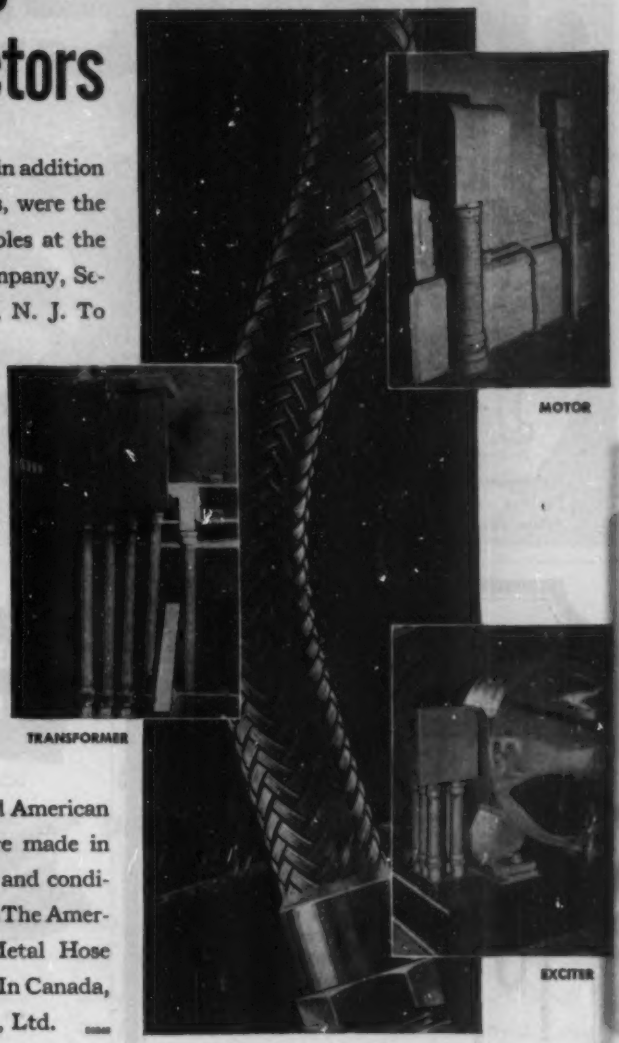

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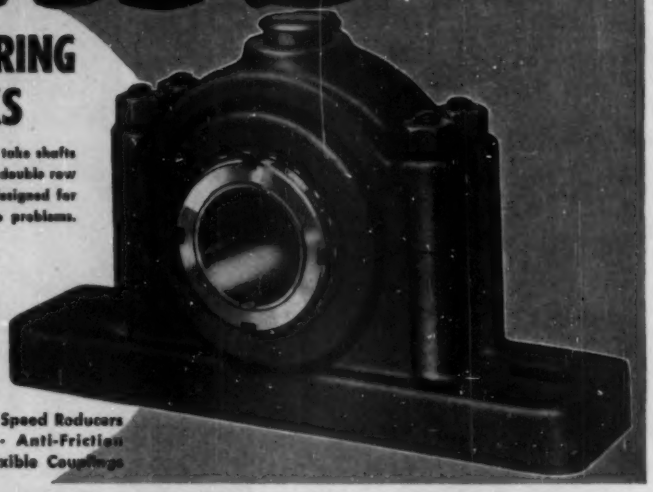

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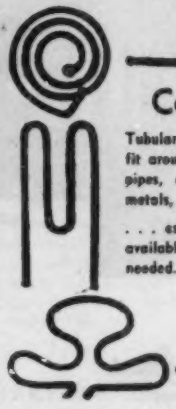

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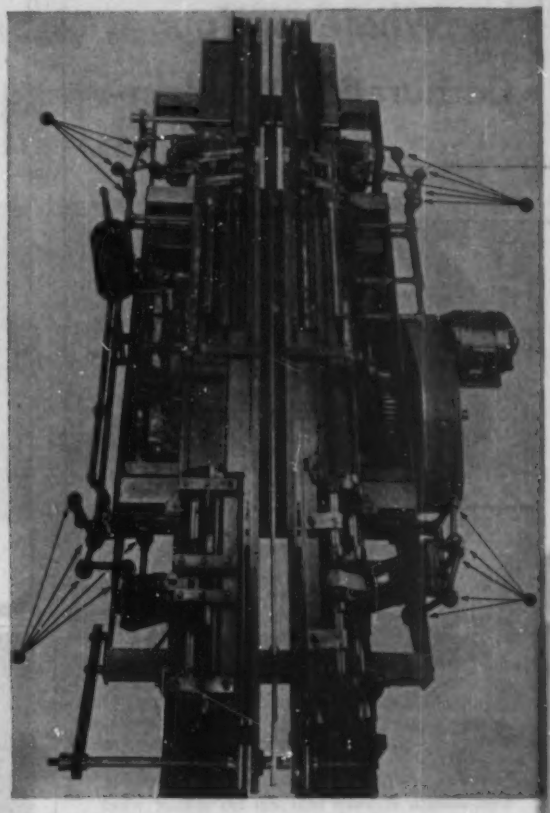

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VOLUME	Cubic inches per rev. output, shaft	1.27
	G.p.m. per 100 r.p.m. output, shaft	.55
	G.p.m. at max. r.p.m. output, shaft	16.8
	Volumetric efficiency, % of max. r.p.m.	93
TORQUE	Pound-inches per 100 p.s.i.	24
	Pound-inches at max. p.s.i.	510
	Stalled or starting torque, % of max.	88
	Running torque, % of max.	93
HORSEPOWER	Per 100 r.p.m. at max. p.s.i.	.96
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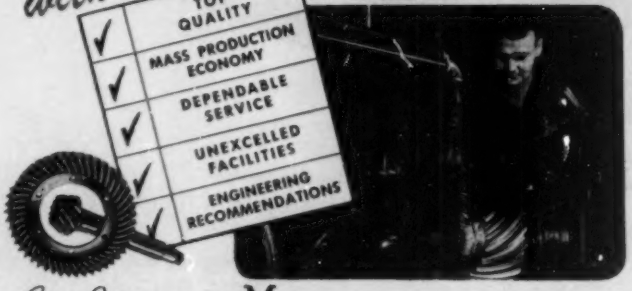

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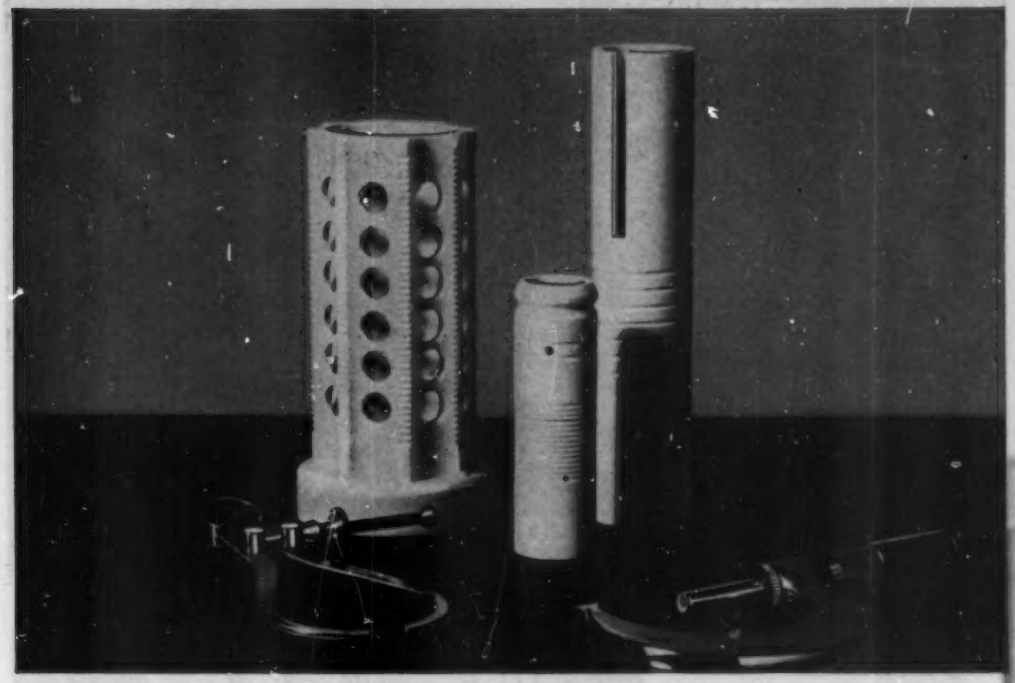

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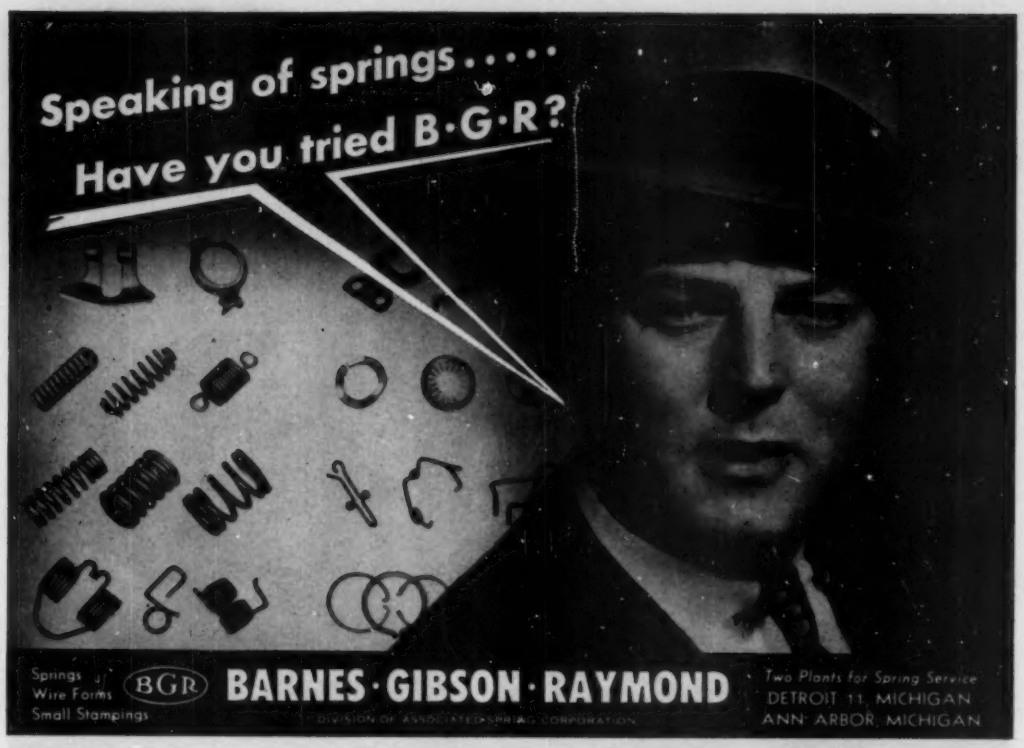

New Bulletin

PRESENTS NOPAK "SERIES 1500" HIGH PRESSURE HYDRAULIC CYLINDERS

Designed for heavy duty service at high pressures, the New 1500 Series embodies features which contribute to long-range dependability and trouble-free operation. Included are: Positively Locked Piston Assembly, Tubing Flanges secured by Lock-Rings, Compensating Rod Wipers, "O"-Ring Static Seals between heads and tubing. Available in 5 standard mountings, with or without Adjustable Cushioning.

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WRITE FOR NOPAK BULLETIN HC-1

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VALVES AND CYLINDERS
DESIGNED for AIR and HYDRAULIC SERVICE

Representatives in Principal Cities

THE prominent compressor manufacturer in whose plant this picture was taken saves time and cost on his assembly line by using TAPER-LOCK Sheaves.

To mount TAPER-LOCK *just slip it on the shaft, line it up and tighten the screws while sighting.* It's in place to stay on the first try. And — it comes off just as easily as it goes on — tomorrow *or years later!* No machined surfaces are exposed to corrosion.

You, too, may profit by using TAPER-LOCK on your product — and on the production machinery in your plant. TAPER-LOCK Sheaves run true — they grip the shaft with firmness equal to a shrunk-on fit. Closer mountings are possible because there are no flanges or collars.

Ask your Dodge distributor about TAPER-LOCK V-Belt Drives, Dodge Bearings, Clutches, Couplings — and the new Dodge Torque-Arm Speed Reducer.

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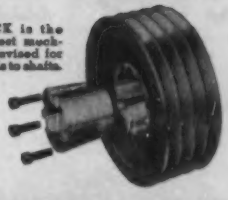
He's factory-trained to help solve your power-drive problems. Look for his name under "Power Transmission Equipment" in your classified telephone directory.

TAPER-LOCK is the simplest, surest mechanism ever devised for holding wheels to shafts.



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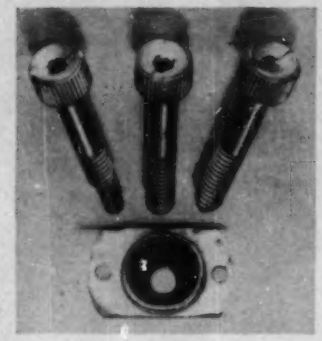
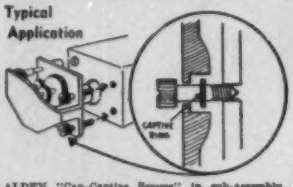


Patent Pending

Typical Application



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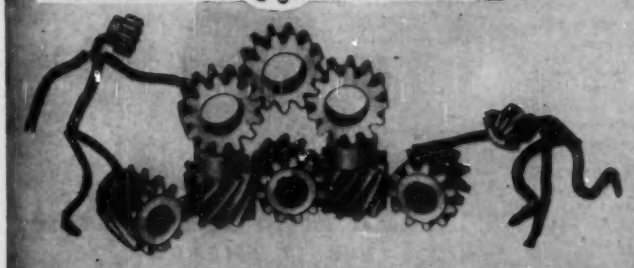

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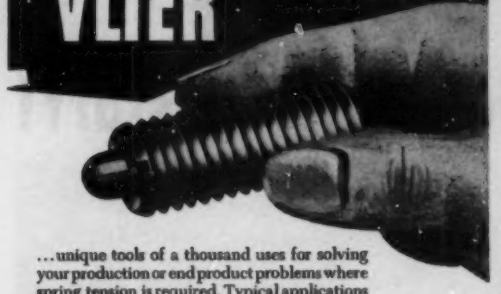

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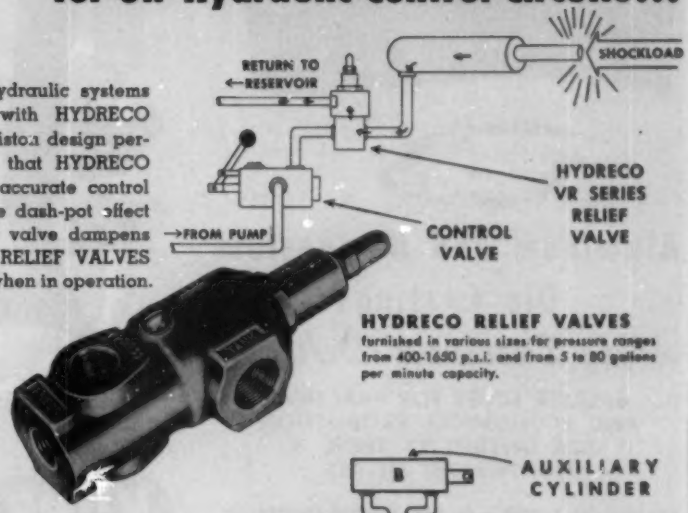

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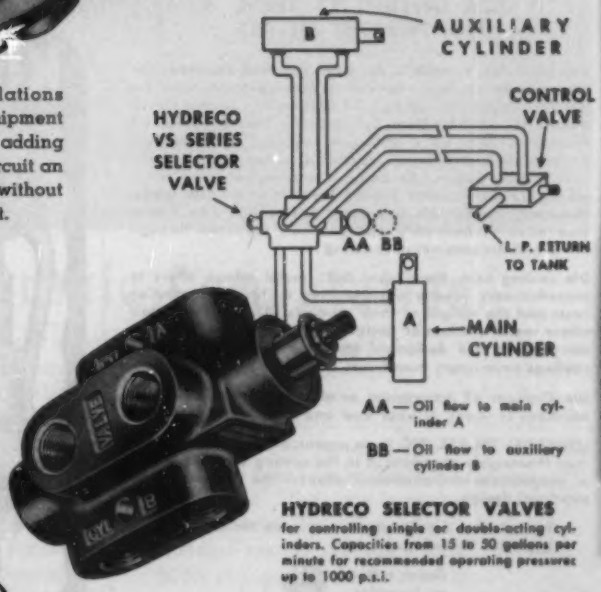

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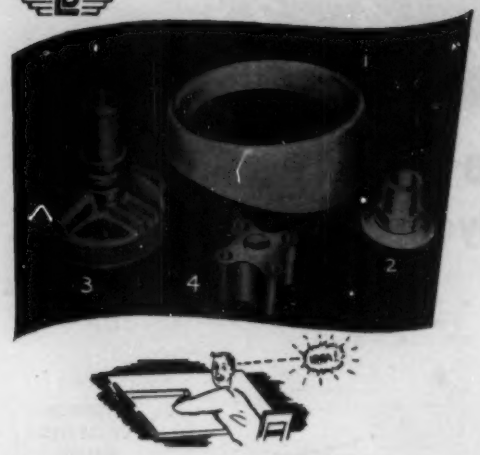

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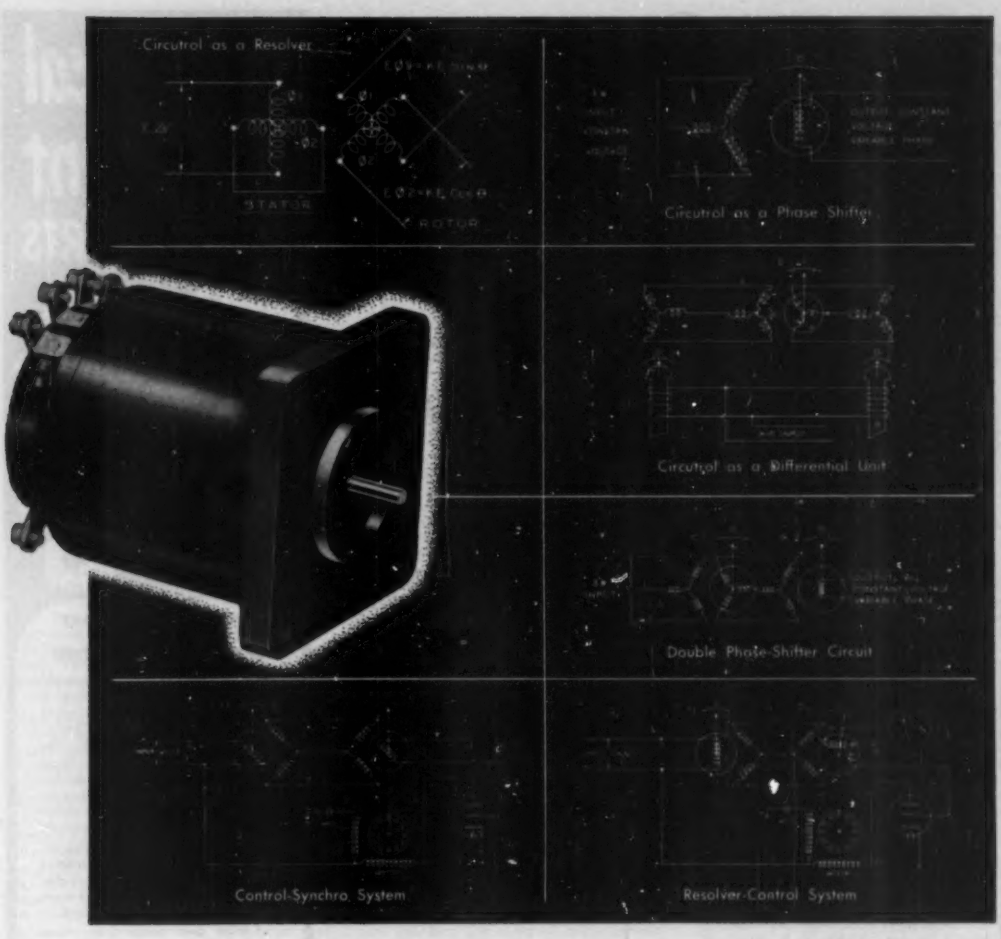

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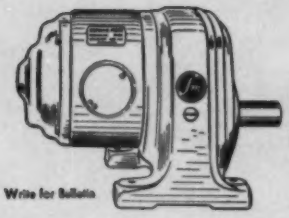

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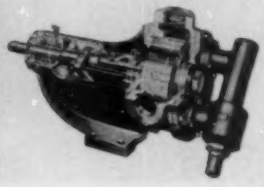

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Conformability

THE tolerance of adjustment to loading or misalignment is known as conformability. If a bearing could be kept in perfect alignment with the shaft it supports and if an oil film could be maintained at all times, there would be no need for more than one bearing material. This ideal bearing material would be hard so that it would resist changes in load that would be expected in normal machine operations, whether these be starting loads, firing loads or loads due to work of the machine.

Actually it is well known that perfect alignment is seldom attained. Tolerances alone, if they are all in an unfavorable direction, can add up to slight misalignment. The tolerance in location of a hole, plus the tolerance of the bore, plus the tolerance of the bearing wall, plus the tolerance of the shaft, presents a difficult problem for the design engineer.

Part of the problem is solved by selection of a proper bearing material. Advantage is taken of a different kind of tolerance—a tolerance of the bearing material to move and adjust itself to unfavorable loading or to slight misalignment.

Conformability is also very important if the oil film is broken and perfect lubrication is lost for a short period. As soon as the oil film is broken the local bearing area starts to heat and local dimensions change. If the material is conformable it will move to better support the load. Then when the oil film is reestablished the bearing will run cooler than before. These are some of the changes that take place during break-in and explain why a bearing will change and even show signs of distress in the first few hours of running and yet run many hundreds and even thousands of hours with little change after break-in.

In general, soft materials conform so that conformability is an inverse function of hardness and is thus best in the babbitts. Unfortunately if a material is too soft, it will move under high loads and the properties of conformability must come to a compromise with the properties of load carrying capacity and fatigue resistance which are associated more with hard materials than soft materials. A compromise for this situation is to use a thin layer of a soft babbitt on a harder backing such as bronze or steel. Then the harder backing will carry the load while the thin babbitt will furnish desirable bearing properties and yet carry higher loads due to its thinness.

For higher loads bronze on steel is used. Conformability is sacrificed at the expense of gain in load carrying capacity with the necessity of design for more ideal conditions for beasing operation.

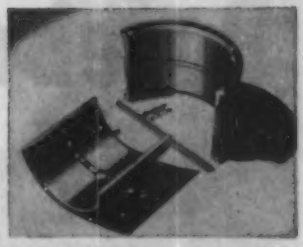
In the use of steel backed bearings, conformability is lost because the steel has less ability to conform compared to the bearing materials used at the running surface. If the lining material is soft it will conform, but if it must be thin conformability is limited.

Relative Comparison of Conformability

Relative properties of bearings based on wide bearing experience showing relative conformability and tolerance to scoring at expense of low fatigue resistance and low load carrying capacity. The relative position of a bearing material will change from this generalization with the composition of the alloy, for instance the amount of lead in a leaded bronze. It will also change remarkably with the thickness of babbitt on a backing material.

SOFT MATERIALS
High Conformability
Low Tendency to Score
Low Load
Low Fatigue Life

HARD MATERIALS
Low Conformability
High Tendency to Score
High Load
High Fatigue Life



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A bearing cannot be selected on the basis of one desirable property. If very high loads are required fatigue resistance and load carrying capacity take precedent. If corrosive conditions are encountered the selection of alloys is limited. The proper bearing material must be selected to best fit the operating conditions.

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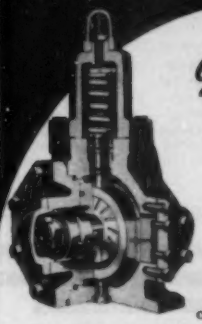

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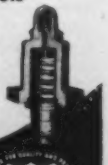
Maximum circuit efficiency and flexibility originate in the hydraulic pumping unit. RACINE Variable Volume Pumps, with built-in governors, deliver only working oil. There is no by-passing—no relief valves, no excessive heating, no waste of horsepower. Write for the new, 3-color catalog. Address Racine Tool & Machine Co., 1772 State Street, Racine, Wisconsin.

Interchangeable Governor Controls

RACINE Variable Volume Pumps are available with governors for hydraulic, manual, mechanical or electric control.



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STANDARD FOR QUALITY AND PRECISION

Job File No. 194

MALLEABLE NUT PRODUCTION

Fully Automatic

CONTROLLED BY T-J CYLINDERS

All moving parts are controlled hydraulically by T-J Cylinders —on this Malleable Nut Production Machine designed and built by Roy Hays & Associates, Rockford, Ill., for the Wagner Malleable Products Co., Decatur, Ill.

It's *fully automatic*—the operator only places nuts in stations. Nine T-J Cylinders, 40 ton to ⅛ ton, help complete the job of cutting off sprue, sizing, boring, facing, chamfering and threading 2,500-¾ std. pipe thread nuts per hour.

For your tough jobs of power movement —pushing, pulling or lifting—*save labor, speed production* and *cut costs* with T-J Air and Hydraulic Cylinders! Many standard sizes and styles . . . both cushioned and non-cushioned types . . . 100 lb. or 50,000 lb. Precision-built for long-life dependability. Write for latest catalogs. The Tomkins-Johnson Co., Jackson, Michigan.

FOR POWER MOVEMENT IN ANY DIRECTION

100 LB. or 50,000 LB.

32 YEARS EXPERIENCE

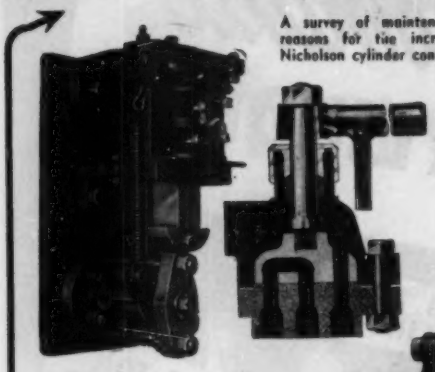
T-J

TOMKINS-JOHNSON

RIVETORS · AIR AND HYDRAULIC CYLINDERS · CUTTERS · CLINCHERS

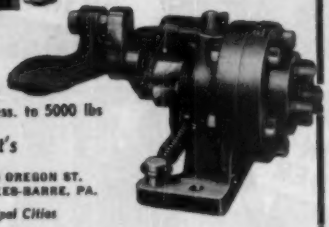
NICHOLSON CONTROL VALVES *feature*

EASY MAINTENANCE



A survey of maintenance men shows these 6 reasons for the increasing standardization on Nicholson cylinder control valves:

1) Specially treated hard seats; don't cut out.
2) Seating surfaces protected from dirt, grit.
3) Metals, gaskets and gland packing to suit service.
4) Generous stuffing box, easily repacked.
5) Heavy-bodied, take abuse.
6) Simplicity of design, minimizes maintenance time.



Nicholson standard and special valves in lever, foot, solenoid, motor types; for air, gas, oil, steam, water; size ¼" to 2½"; press. to 5000 lbs

Bulletin 546 or see Sweet's

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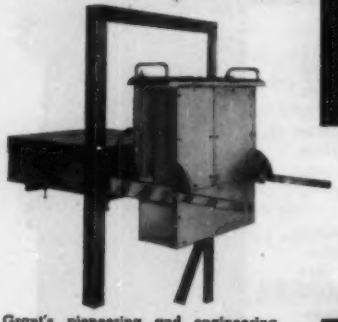

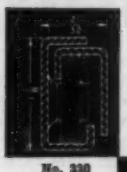

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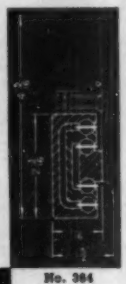

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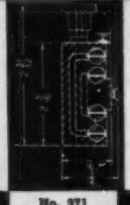

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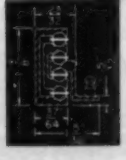

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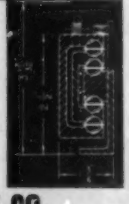

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FEATURES

SENSITIVE — Relay action initiated by external contact as high as ONE HALF MEGOHM with current as low as 1/10000 ampere.

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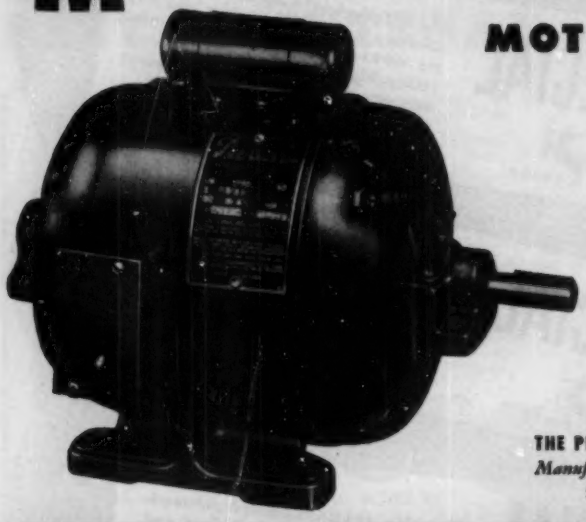

● When you bring your motor problems to Peerless Electric, you add a motor department to your plant facilities. Peerless is small enough to give individual engineering attention to your motor requirements—large enough to manufacture the motors you need in any quantity.

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Single Phase • Polyphase • Direct Current Motors

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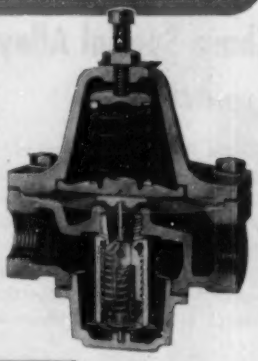
stopping ONE HEADACHE...

Once you have chosen Cash-Acme valves as component parts of your factory equipment, you can stop worrying about valve failures or sudden disaster.

We invite you to investigate Cash-Acme direct acting single seated pressure reducing valves for steam . . . water . . . air . . . or gas lines.



Type B valve. For full information, request catalog 144.

CASH-ACME *Automatic Valves*

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SAVING 25%—STRONGER FASTENINGS. Durant Mfg. Co. uses several P-K products to advantage in their Productimeter. Four Type F Self-tapping Screws fasten the mounting plate to the cover frame, two Phillips Recessed Head P-K Type Z Screws fasten the cover to counter frame, and another fastens the spring to the counter arm. The manufacturer says, "Only with P-K Screws could we get the simpler, speedier, stronger fastenings we wanted." Wing Nut on end and Set Screw in arm are also P-K. Find out how you can make similar savings. Talk to a P-K Assembly Engineer.

Don't let screw failure cancel savings

TYPE F
(Also made with Phillips head)

Three steps are needed to *insure* assembly savings. First, engineer your assembly for minimum cost. Next, select the simplest, speediest fastening method. Then, if as in most cases, you find this to be with Self-tapping Screws, use the best that money can buy. For, if screws run offsize, if they break or otherwise fail, all your carefully *planned* savings are lost.

Choose P-K Screws ... avoid slowdowns and scrapped parts

NEED SPECIAL SMALL SIZE SELF-TAPPING SCREWS WITH PHILLIPS RECESSED HEADS?

P-K Type A or Z, in No. 0 or No. 1 diameter, with a No. 0 Phillips Recess, can be made to order, quantity permitting.

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Remember, the actual cost of screws depends, never on price, *always* on performance. Specify Parker-Kalon, and you'll see why the makers of thousands of the nation's best known products say—IF IT'S P-K . . . IT'S O. K.!

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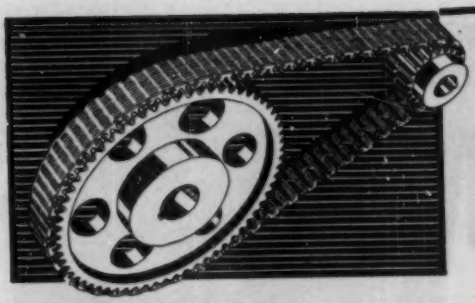
P-K TRADE MARK

The Original
PARKER-KALON* SELF-TAPPING SCREWS
A TYPE AND SIZE FOR EVERY METAL AND PLASTIC ASSEMBLY



WHAT IS YOUR DRIVE PROBLEM?

HIGH SPEED?
A Ramsey Chain will operate at speeds higher than any other make of chain or other type of transmission. Lack of friction makes this possible.

LUBRICATION?
A Ramsey Chain requires no more lubricant than you would give a frictionless bearing. No oil bath necessary with resulting oil leakage.

POSITIVE RATIO?
Positive contact between chain and sprockets insures full delivery of power at predetermined speeds. No slippage as with any type of belt. No waste of power.

SPACE RESTRICTIONS?
Ramsey Drives are compact. They can be installed on short centers with sprockets of small diameters and housed in the body of the machine.

These features and many others are made possible by the joint construction—the heart of a silent chain. Look at the illustration below of the Ramsey Roller Bearing Joint. It's different. There is no silent chain like it. A Ramsey Chain, with this joint in every link, means smooth operation, maintenance cut to the bone and long life to the drive. It will be to your advantage to investigate NOW.

See how it ROLLS . . .

Note that the two pins engaging the links of the chain have rolling surfaces similar to those of rollers in a roller bearing in contact with their raceways. This patented Ramsey feature assures a free-moving, friictionless joint with least possible lubrication.

SEND FOR A COPY of the 60-page fully illustrated Ramsey Application Manual. It will show you how easily you can improve your product by improving the drive.

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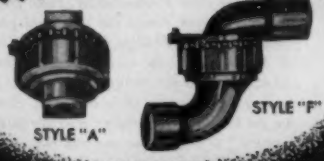
For Moving Pipe Lines Safe • Dependable FLEXO JOINTS



- **INDISPENSABLE . . .** for conveying fluids through movable pipe lines or equipment in motion! Complete 360° movement—with no flow restriction. Four styles for standard pipe sizes ¼" to 3".
- **ECONOMICAL . . .** simple in design, Flexo Joints contain no springs, no small or loose parts—assure long wear, extremely low maintenance cost.
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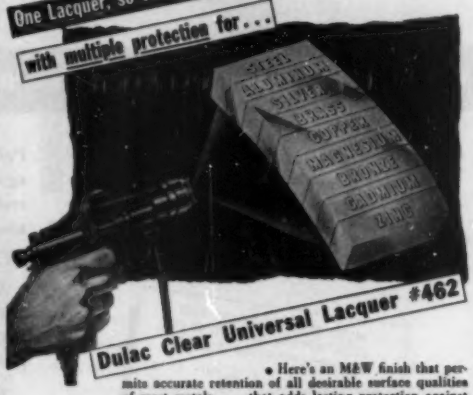
One Lacquer, so clear it's invisible,
with multiple protection for . . .



Dulac Clear Universal Lacquer #462

• Here's an M&W finish that permits accurate retention of all desirable surface qualities of most metals . . . that adds lasting protection against heat, cold, weather, corrosion, stain and perspiration — Dulac Clear Universal Lacquer #462. It's formulated to give good adhesion with either the spray, dip or brush method. And it fits into fast production schedules because in five to ten minutes this successful general purpose lacquer dries out of dust . . . hardens in one hour. For complete information, write for Technical Data Bulletin 110 or let an M&W technical consultant discuss your requirements privately with you.

. . . where industry goes with finishing problems

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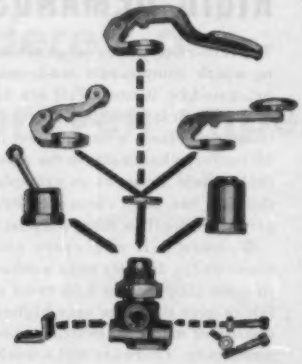
* Fluid Power Improves Production

NEW LOGAN AIR CONTROL VALVES

• Dual Mountings
• Five Types of Control



Type of activation of any valve in the 6200 or 6300 Series may be changed to suit the requirement simply by adding above parts as desired to the basic valve.

FREE ENGINEERING SERVICE

Ask Logan engineers for valuable assistance in designing complete air circuits and in selecting effective types of equipment. No obligation.

Series 6200 2- and 3-Way Valves

Real economies may be achieved in a wide variety of standard applications with these new, highly compact 2- and 3-way ¼" port air valves. Also practical for many specialized jobs. May be equipped with any of five types of controls. Designed with dual mountings.

The 6200 series is manufactured with three ports, one of which may be plugged to make a 2-port valve. They are designed for remote control of bleeder- and pilot-operated master valves, single-acting air cylinders and many other similar uses.

Series 6300 4-Way, 2-Position Valves

These new ¼" port Logan valves have the same construction features and advantages as the 2- and 3-way valves: five types of controls; dual mountings. Practical for a wide range of standard applications and for many specialized jobs. All ports and internal passages are full pipe size. All parts are corrosion-resistant. The valves can be located in any desired position.

• *Write For This New Logan Catalog* •

Write today for your free copy of the new Logan Catalog No. 100, Section 4. Contains complete listing plus illustrations and diagrams.

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4-Way Model 6350

4-Way Model 6368

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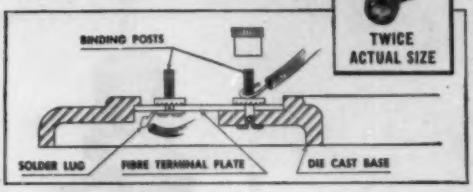
for a lot of big jobs

TWICE ACTUAL SIZE



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A combination tubular rivet and threaded post, the connector eliminates separate parts such as nuts and lock-washers, excludes expensive hand operations and permits multiple assembly. Made of headed stock, it curls without cracking. Serrations lock the post to keep it from turning. Tubular section holds the post to its base and may be used further to hold a soldering lug, etc. Drawing detail above shows the multiple functions performed by the fastener.

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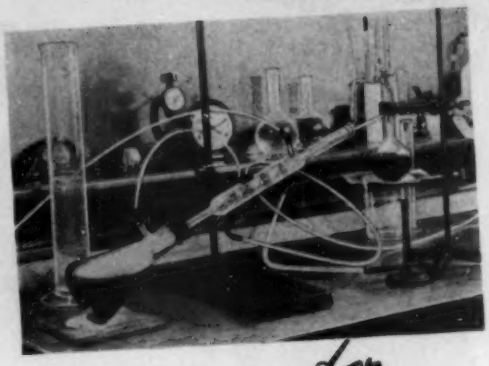

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MEETING RIGID DEMANDS

The remarkably wide range of uses to which components made and processed by Western Felt are astonishing. It is serving in scores of industries—from women's hats to 50 ton forge hammers. In the automobile field alone, as an example, this felt has been chosen to best serve in more than thirty purposes.

Western Felt engineers and chemists for decades have worked in close cooperation with users of felt to give them the very highest quality of material, exactness and uniformity. There are still a world of potential uses for Western Felt products, made to almost any shape, size or consistency. They range from wool softness to rock hardness. When cut, it does not fray or lose shape. It can be cut to close tolerances for such products as gaskets, washers, channels, grommets, filters, seals, etc. It can be made waterproof and fungus-proof and flame resistant. It will pay you to place your felt requirements in the experienced hands of Western Felt. Its counsel and products will prove profitable.

Acadia Synthetic Products Division, WESTERN FELT WORKS, Processors of Synthetic Rubbers—Sheets, Extrusions, Molded Parts.

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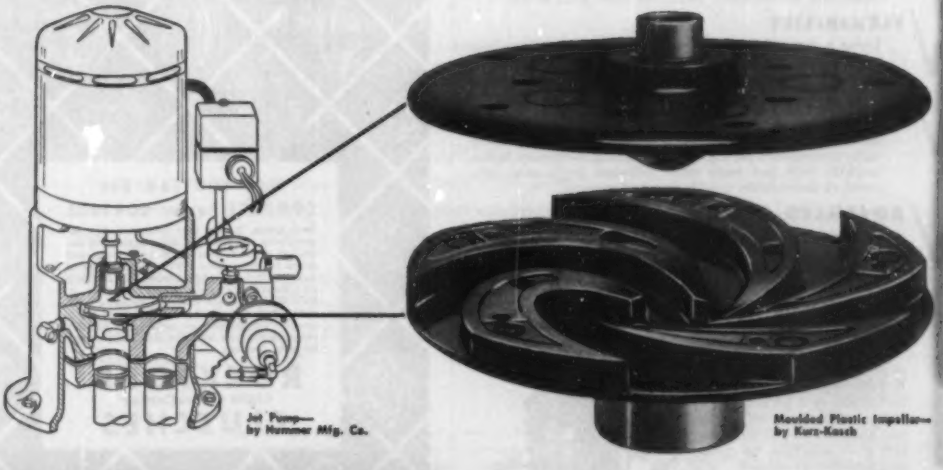
Constantly immersed in water—perfectly balanced for vibrationless high-speed performance—Kurz-Kasch moulded plastics take on a new pumping job with the same old, proved results: tip-top performance and low-down cost. Just ask Hummer Manufacturing Co., makers of an outstanding line of quality jet pumps.

It's their centrifugal impeller that you see here—the single moving part in one of the most efficient types of modern well pumps—actually, the heart of the entire mechanism. It used to be made of forged or sand-cast brass. Inasmuch as it revolves at 3500 RPM, finishing operations were extensive, including machining, hand-finishing of water passages, and balancing. Results were good generally, but expensive—so Hummer engineers decided to see if plastics would meet their exacting requirements.

This job does it, performance-wise and cost-wise both! It has passed 7 years of laboratory and field tests with colors flying! We recommended an improved high-impact phenolic, moisture-resistant with special resistance to alkalis and acids. We mould it in 2 pieces, with insert and bushing moulded in; cool it in a shrink fixture for a straight, tight, gapless fit. Finishing consists merely of flash removal, facing inserts and riveting.

Look at the difference in costs! Look at what Hummer engineers say about performance! Look—say, if you want a job done for you in plastics, just look our way! We answer inquiries promptly.

Here's a proven impeller in PLASTICS!



Jet Pump—by Hummer Mfg. Co.

Moulded Plastic Impeller—by Kurz-Kasch

Kurz-Kasch

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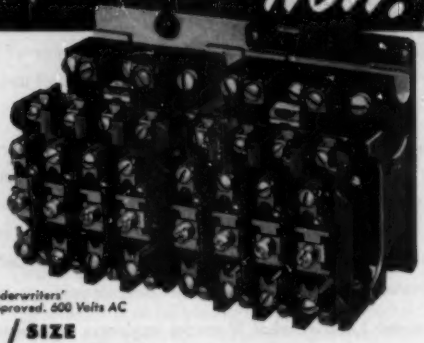


Underwriters' Approved. 600 Volts AC

✓ **SIZE**

Non-Reversing

2 to 4 Pole 2-3/4" w. x 3-5/8" h. x 3-5/16" d.
5 to 8 Pole 5-9/16" w. x 3-5/8" h. x 3-5/16" d.

Reversing

2 to 4 Pole 5-9/16" w. x 3-5/8" h. x 3-5/16" d.

Note: 10 and 15 ampere contactors have same mounting and overall dimensions.

✓ **ACCESSIBILITY**

To replace contacts, it is not necessary to disassemble the complete contactor. Just remove the parts comprising the stationary and movable contacts. Contacts can be replaced without disturbing wiring. To change coil, remove magnet frame and coil assembly only. (See illustration below.)

✓ **FLEXIBILITY**

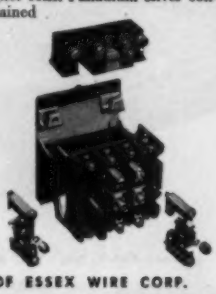
Using a screw driver only, you can easily change any pole from normally open to normally closed. No special parts required. 10 and 15 ampere parts are interchangeable.

✓ **RELIABILITY**

Laboratory tests involving millions of operations, plus field service of thousands of R-B-M contactors on door operators, radio transmitters, packaging and weighing machinery, hoists, machine tools and many other industrial applications offer proof of dependable, trouble-free performance.

✓ **ADVANCED DESIGN**

Melamine Insulation. Molded coil housing. Ilsco solderless connectors. 50/60 cycle magnet coils. Palladium silver contacts. Stainless steel self-contained contact springs.



Where space is a factor, and accessibility a must—use R-B-M industrial contactors. Initial low cost plus dependable performance will save you money. Write for Bulletin 600 and price list on your company letterhead.

Dept. C-5 R-B-M DIVISION OF ESSEX WIRE CORP.
Logansport, Indiana

RBM

MANUAL AND MAGNETIC ELECTRIC CONTROLS
FOR AUTOMOTIVE, INDUSTRIAL, COMMUNICATION AND ELECTRONIC USE

TRACING CLOTH FOR HARD PENCILS

● Imperial Pencil Tracing Cloth has the same superbly uniform cloth foundation and transparency as the world famous Imperial Tracing Cloth. But it is distinguished by its special dull drawing surface, on which hard pencils can be used, giving clean, sharp, opaque, non-smudging lines.

Erasures are made easily, without damage. It gives sharp, contrasting prints of the finest lines. It resists the effects of time and wear, and does not become brittle or opaque.

Imperial Pencil Tracing Cloth is right for ink drawings as well.

IMPERIAL PENCIL TRACING CLOTH

SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE

How YOU CAN Get
COMPACT Power CONTROL
Save space, in your next product design, by specifying a ROCKFORD engineered-to-the-job clutch — that will fit your power and space needs, exactly. With a wide range of sizes and types to choose from, ROCKFORD engineers are able to recommend a ROCKFORD clutch that will conserve both space and power. Send a blueprint for a specific suggestion — or write for a bulletin covering the type and size clutch best suited for your product.
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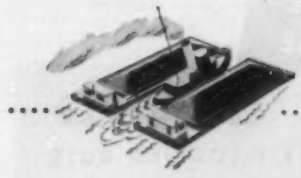
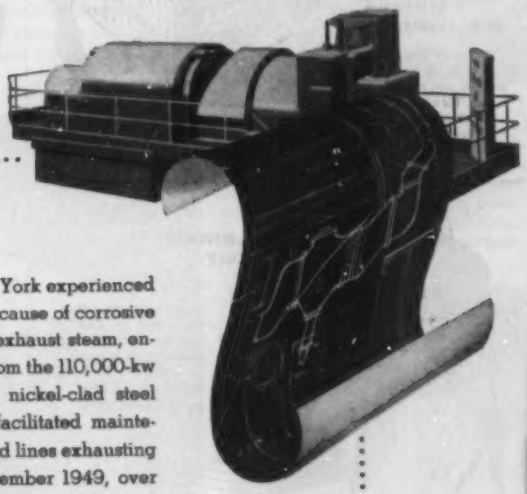
ONE OF A SERIES DEMONSTRATING APPLIED LUKENOMICS

DEDUCTING MAINTENANCE

...or how to insure long life in high-temperature exhaust ducts

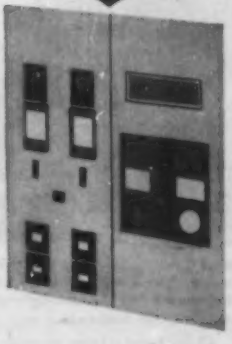




A Consolidated Edison Company plant in New York experienced costly failures in atmospheric exhaust ducts because of corrosive and erosive action developed in discharging exhaust steam, entrapped gases and chlorinated salt tidewater from the 110,000-kw turbines and auxiliary equipment. In 1946, nickel-clad steel ducts were installed. Their modern design facilitated maintenance by permitting shorter flanges for two feed lines exhausting from the auxiliary lubrication pumps. In December 1949, over three years later, the ducts were found to be in excellent condition, and savings had more than returned original installation costs.

Such strides in equipment design in the last two decades have resulted in increased efficiency . . . lower maintenance and operating costs . . . improved performance. Many of the improvements have been the result of the cooperation between engineer, designer, fabricator and materials supplier. We call this *Lukenomics*. Such an approach is at your disposal to help solve your cost and amortization problems along with other vital considerations.

To obtain the advantages of equipment built by fabricators applying the Lukenomics principle, write our Manager of Marketing Service, Lukens Steel Company, 405 Lukens Building, Coatesville, Pennsylvania.

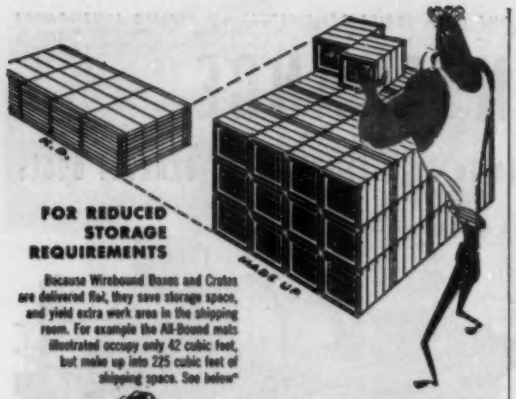


A nickel working surface is so satisfactory for exhaust duct service that Consolidated Edison Company of New York is standardizing on this design. For maximum economy the ducts are fabricated of Lukens Nickel-Clad Steel.

LUKENS

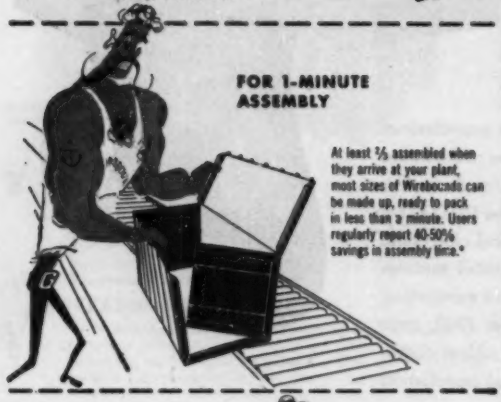
LUKENS STEEL COMPANY

BETTER PRODUCTS FOR BETTER EQUIPMENT



FOR REDUCED STORAGE REQUIREMENTS

Because Wirebound Boxes and Crates are delivered flat, they save storage space, and yield extra work area in the shipping room. For example the All-Round mats illustrated occupy only 42 cubic feet, but make up into 225 cubic feet of shipping space. See below*



FOR 1-MINUTE ASSEMBLY

At least ⅔ assembled when they arrive at your plant, most sizes of Wirebounds can be made up, ready to pack in less than a minute. Users regularly report 40-50% savings in assembly time.*

FOR BETTER, SAFER STACKING

The versatility of the Wirebound principle—the strength of steel combined with thinner wood—permits variation of wire gauges, staple spacing, battens and cleats to provide safe structural strength for large and small containers to meet all warehousing requirements. Note*

USE Wirebound BOXES & CRATES FOR LOWER TOTAL SHIPPING COSTS

60 Wirebound Plants throughout the United States

*Send for this free book! *Explains in detail Wirebound principles, advantages, features and describes how Wirebounds are designed to suit every size and shape of product. Mail coupon today.*

Wirebound Box Manufacturers Assn., Room 1820, Borland Bldg., Chicago 3, Ill.

☐ Send Booklet of Product Information ☐ Send a Sales Engineer

NAME

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OUR PRODUCT IS

FLEXLOC

ONE-PIECE SELF-LOCKING NUTS

The FLEXLOC is one-piece, all-metal . . . has ample tensile and long life. It is a Stop and Lock-Nut that can be reused many times. Its "chuck-like", resilient locking segments lock the FLEXLOC securely in any position on a threaded member. It positively "won't shake loose", yet can be removed easily with a wrench.

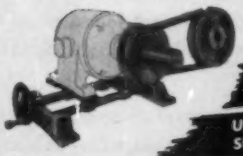
Write for Catalog 619, it's full of information.

SPS STANDARD PRESSED STEEL CO.
JENKINTOWN 28, PENNSYLVANIA

VARIABLE SPEED

ROTO-CONE Variable Speed Devices

Proven Design

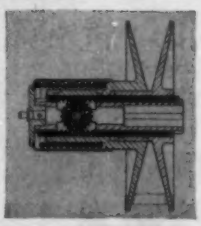


CONSTANT BELT CENTERLINE

UP TO 4 TO 1 SPEED RATIO

V TO V DRIVE Sizes ⅛ to 10 h.p.

Of proven design, Roto-Cone variable speed devices can solve your speed-change problems by adding to the productivity, flexibility or saleability of your product. Exclusive rack and pinion arrangement provides equal lateral movement of both discs, therefore belt alignment is constant. Unit is easy to install in any position. Roto-Cone drives include variable speed pulleys, V-groove driven sheaves, wide V-belts and adjustable motor bases.



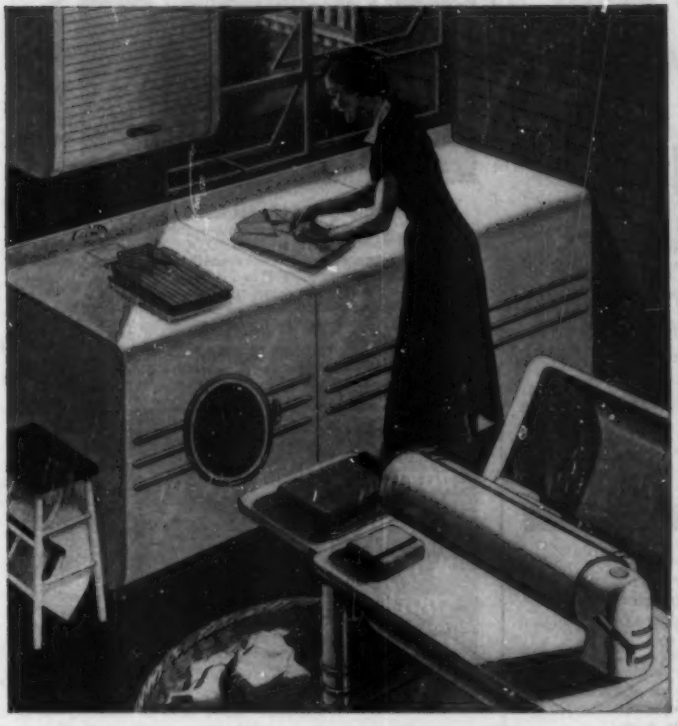
Write for details or request the services of our speed control engineers.

GERBING MANUFACTURING CORP.

The day drudgery went out of style!

Problem: Housewives hated the drudgery and scrubbing needed to keep their home laundry clean. Manufacturers wanted easy-to-clean finish.

Solution: Industrial Finish Engineers put this drudgery out of style by developing a special finish for automatic laundry equipment and other appliances that can be cleaned quickly with damp cloth. This finish does not chip—is heat-resistant—takes less time to apply and dry than old finishes. A cost-saver.



Problem: To find ways to decrease the unit cost of bicycles.

Solution: Industrial Finish Engineers developed a special finish that permits shorter baking time, cutting down production costs. This high-gloss finish has a permanently hard finish that is mar-resistant.

Problem: How to cut cost of wiring electronic devices.

Solution: Industrial Finish Engineers developed special metallic finish which is good conductor of electricity. This eliminates painstaking method of laying wires—saves production time—cuts costs.

Problem: To find an inexpensive way to give overshoes a gleaming surface.

Solution: Industrial Finish Engineers developed a special elastic, durable finish. This finish is baked on in the same operation that cures the rubber. Saves time. Saves money.

Save time — cut costs through Industrial Finish Engineering!

This may be your chance to cut your manufacturing costs! Lower your break-even point! Save valuable manufacturing minutes!

Industrial Finish Engineering has done these things for many of America's leading manufacturers. Find out, today, what it can do for your product. Contact an Industrial Finish Engineer.

For the Finish Industry has technical ability to make finishes to suit the specific requirements that you need for your products. Remember, most of your customers *start buying with the finish in mind!*

The better the finish—The better the buy!

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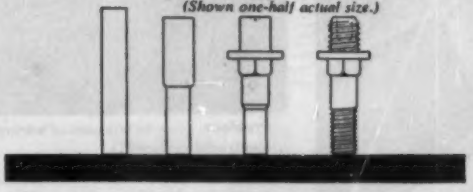
this complex shape is being made at low cost by . . .

actual size

Cold Heading

This special steel stud, used in heavy duty power transmission equipment, combines two different shapes with four diameters.

Some of the steps involved in cold heading this part from a length of steel wire. (Shown one-half actual size.)



Production of this steel part by ordinary methods would involve the use of high cost machines, plus other costly operations. Cold heading not only provides economy and speed of production, but also produces a much stronger part.

Possibly this special technique can help *you* with your fastener problems. Send your sample or blueprint to Scovill *first*.

"Guide to the Profitable Use of Cold Heading"—Bulletin No. 2 describes the advantages and limitations of this process. It's free for the asking.

Recessed Head Screws • Bolts • Tapping Screws
Standard Machine Screws • Special Cold Headed Parts

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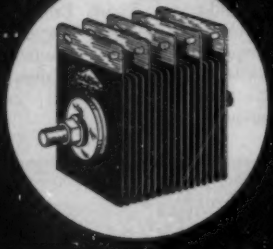

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The only rectifier with Magnesium Radiator Plates. "Lektron" is lighter in weight—handles up to 60 Volts D.C. from 50 to 50,000 Amperes. They're more rugged mechanically, operate at temperatures from —40° F to 284° F and are not affected by normal atmospheric conditions. Complete engineering service available.

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Lektron Rectifiers

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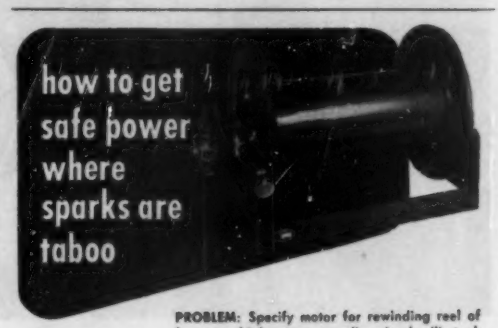
how to get safe power where sparks are taboo



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SEND OUT FOR CATALOG

"AIR MAY BE YOUR ANSWER!"

PROBLEM: Specify motor for rewinding reel of hose on high-octane gasoline (and oil) tank trucks. *Must be 100% safe in explosive atmospheres . . . must run off truck power sources.*

SOLUTION: GAST (Model 4AM) Air Motors connected to truck's high-pressure pneumatic brake system. Developing ¾ H.P., motor is geared down through chain and sprocket.

RESULT: Complete safety with rotary-vane air motor. No sparks — no danger! Variable-speed motor develops plenty of torque for smooth rewinding without jerks.

Many similar — and totally different — engineering problems have been solved successfully with GAST Rotary Air Motors. As original equipment, they offer explosion-proof safety — variable speed from 100 to 6,000 R.P.M. — reversibility — compactness — and other unique advantages. If these features could improve your product, write GAST a brief description of your problem.

GAST ROTARY

AIR MOTORS • COMPRESSORS • VACUUM PUMPS
(TO ONE H.P.) (TO 30 LBS.) (TO 28 INCHES)
GAST MANUFACTURING CORP., 139 Hinkley St., Benton Harbor, Mich.

Mr. Businessman!

WHAT WILL THE 1950 CENSUS DO FOR YOUR BUSINESS?

CONSUMER MARKET INFORMATION

The 1950 Census will provide a huge amount of information about the characteristics of the consumer market. It will tell you what kind of income groups live where . . . what they have and what they need in the way of commodities from automobiles to television sets down to plumbing fixtures. The Census is an accurate survey of economic conditions in your market area. It will not only tell you *where* your customers are, but *what they need that you have to sell them!*

It will show where improved transportation and shipping facilities are needed . . . better harbors and waterways . . . stepped-up Public Service.

That is why the 1950 United States Census is vital to your business!

COOPERATION

You know that the Census-Taker is not just "counting heads." He's actually making a survey of existing conditions in industry, business, employment, housing, education. *You* know census information is as confidential as the vote you cast! Because you know all these things *you'll* cooperate with the Census-Taker in every way when he calls on you.

WHAT ABOUT THE OTHER FELLOW?

But! What about the people who work for you? The man in the shop . . . your own secretary . . . the fellows in the shipping room. Do they know all this about the Census? Chances are some of them do, so the idea is to get the right information across to those who don't!

WHAT'S THE BEST WAY?

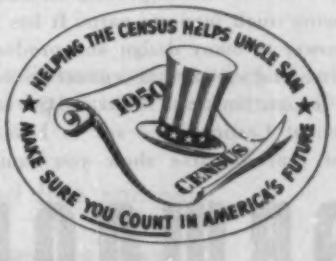
If it's possible, call everyone together and talk about it . . . ask questions . . . exchange ideas. If your outfit is too big for that, direct a Census information memorandum to all your employees. Post information on the bulletin boards. Run a Census story in the company house organ. Talk about it. *Every way you can . . . get the people who work for you to cooperate with the Census.*

WHAT DOES THE 1950 CENSUS MEAN TO YOUR EMPLOYEES?

Better schools . . . school buses . . . school lunches. It means finer roads, bridges and highways . . . increased transportation facilities . . . improved safety regulations. It creates more efficient Public Service and furthers adequate distribution of utility services such as telephones, gas, water and electric power. It will help your community plan better parks, playgrounds, recreation areas and housing. It will mean higher living standards and accurate congressional representation. The Census is *everybody's voice in America's future!*

YOU OWE IT TO YOURSELF . . .

Mister Businessman . . . to your business and your community! Put your efforts behind the 1950 United States Census for an even better country to live in . . . the *best* country to do business in!



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An Arwood casting saves 50%

Here is a typical example of what ARWOOD precision castings can do. Such results are made possible only by ARWOOD'S years of experience that spells "know-how."

Five parts — 2 stamped and 3 machined -- formerly had to be brazed together to make the bronze key guide housing shown at left above. The Lathem Time Recorder Co. reports their costs were reduced 50% when a single ARWOOD Precision Casting replaced the five-part assembly.

The key shown at right is also an ARWOOD Precision Casting which fits the keyway without any adjustment.

ARWOOD Precision Investment Casting is now a tested and important method for producing small intricate parts. It has been the answer to many design and production problems and can be the answer to yours. Write for our booklet, "A Critical Survey of Investment Castings," or ask to have our nearest representative show you samples.

ARWOOD

PRECISION CASTING CORP.

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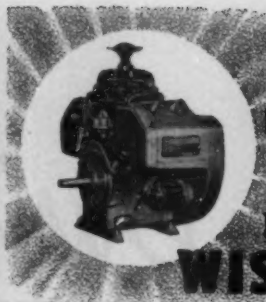

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PEAK PERFORMANCE
15 to 30 H. P
V-Type Four-Cylinder
WISCONSIN ENGINES

Model VE-4, V-type 4-cylinder standard engine 21.5 hp. at 2400 rpm.

HEAVY-DUTY *Air-Cooled*

On power jobs that call for rugged serviceability and sustained operation in the 15 to 30 hp. range, Wisconsin 4-cylinder engines rate *first preference* on the basis of such features as:

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V-type design permits a shorter crankshaft and less height than with a "straight-in-line" engine, assuring a more compact power unit.

4-cycle single cylinder models, 3 to 9 hp., and 2-cylinder models, 7 to 13 hp., also available. Detailed data on request.

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HIGH EFFICIENCY • LOW POWER CONSUMPTION
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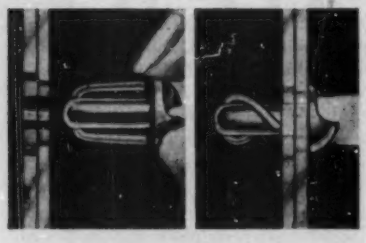
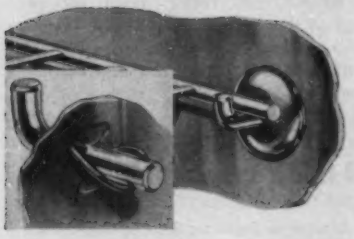


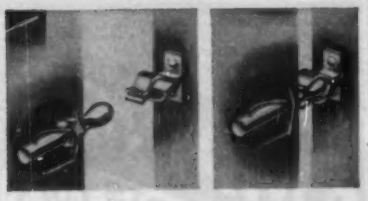
It's a Blind Rivet

. . . Or a removable fastener. It locks and unlocks with a 90° clockwise rotation. No mating parts such as nuts or receptacles are required.



It's a Shelf Support

. . . For ranges or refrigerators. Leading appliance makers have achieved substantial installation savings through its use.



It's a Cabinet Door Strike

. . . Simple to install, eliminates welding and cuts assembly cost. Any head can be designed without affecting fastening principle.

What's Your Application?

. . . Tell us how you can use Spring-Lock Fasteners in your products. We'll be glad to work out the details with you.

Millions of these ingenious Spring-Lock Fasteners are used in electrical, automotive, railroad, aviation and household appliance industries. Design engineers marvel at their utility and flexibility.

Write today for literature and free samples.

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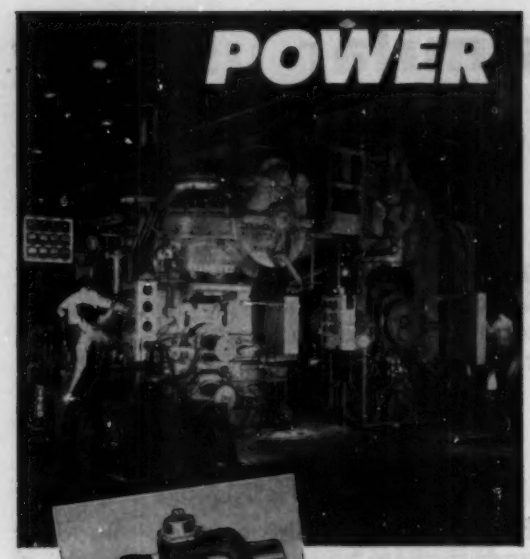
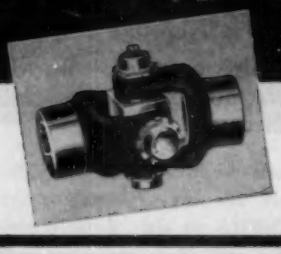
Simmons Fastener Corp., 1751 N. Broadway, Albany 1, N. Y.

SPRING-LOCK • QUICK-LOCK • ROTO-LOCK





for machines that make steel delivered through BLOOD BROTHERS Universal Joints

The BLOOD BROTHERS Universal Joints for this 2-stand Tandem Skin Pass Mill, and for other steel-making products of UNITED ENGINEERING AND FOUNDRY COMPANY, have the characteristics demanded for such machinery: tremendous strength and capacity for excessive shock load or starting load. Each joint and shaft assembly meets the most rigid inspection standards.

For big machines or small, industrial installations or commercial vehicles, wherever power must be flexibly transmitted, BLOOD BROTHERS supply job-specified universal joints that "stand the gaff" through countless hours of rugged duty. Before you specify, check with BLOOD BROTHERS for universals that deliver a bonus value.

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Division of Standard Steel Spring Company

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Precision molding of intricate design in production-run quantities is but one of the advantages of Universal Porcelain Insulators. Additional advantages include a high dielectric factor, strength to withstand physical and thermal shock, resistance to heat, cold, moisture, fumes and most acids; sturdiness to stand up and deliver years of efficient service under all kinds of conditions.

If you require these advantages in the insulators you use, a Universal engineer will be glad to consult with you. No obligation, of course.

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DAYTON ROGERS MFG. CO.
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For over 58 years, Philadelphia Gears have been produced in all sizes, types and materials . . . and, today our plant, machinery, facilities, men, methods and management are better able than ever before to serve you satisfactorily and promptly.

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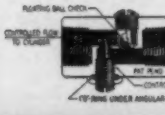

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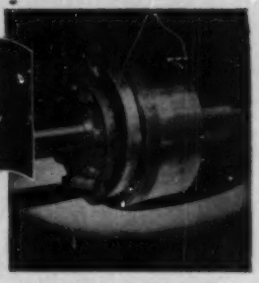

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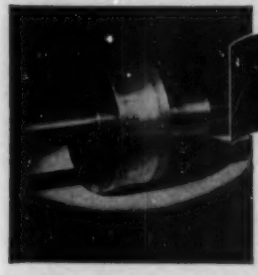

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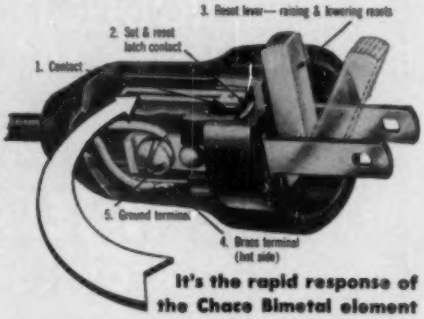

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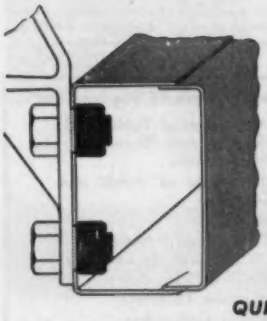

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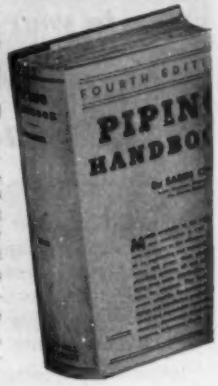

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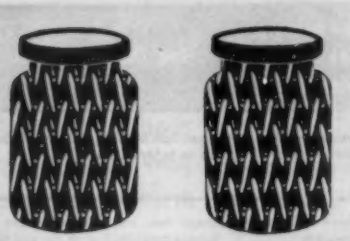

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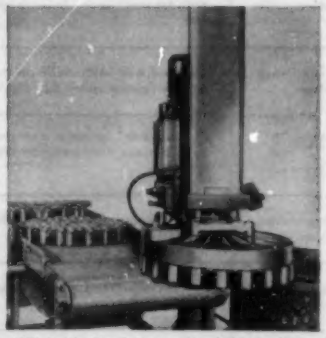

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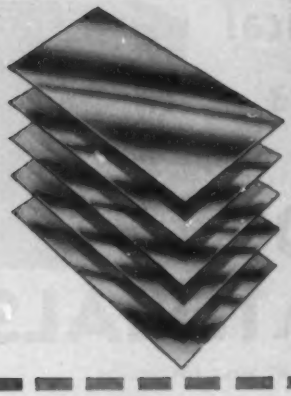

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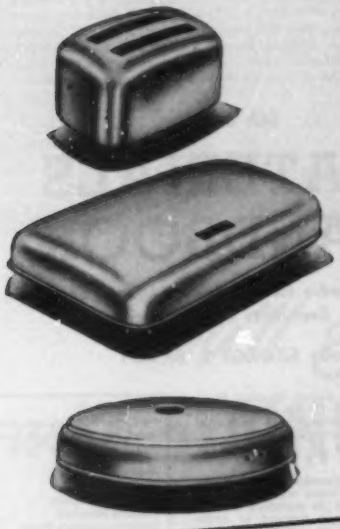

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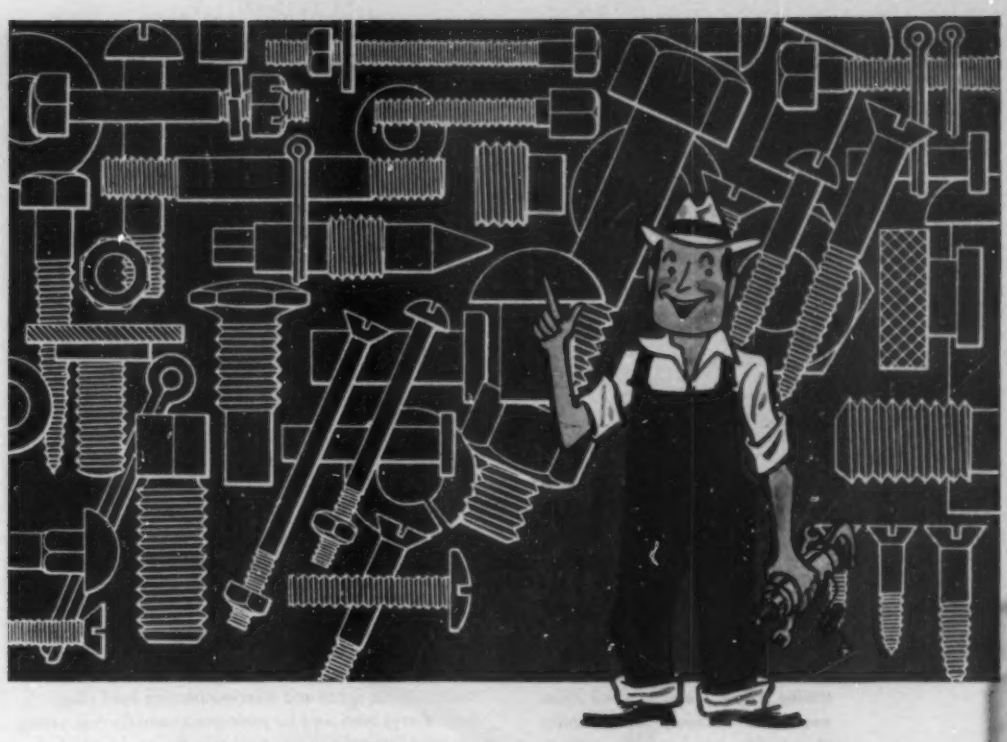

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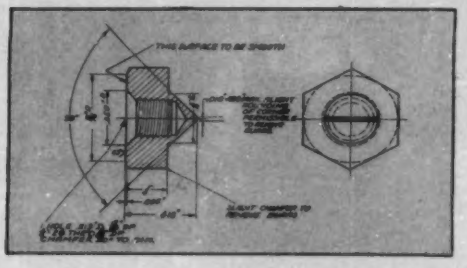

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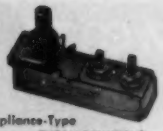

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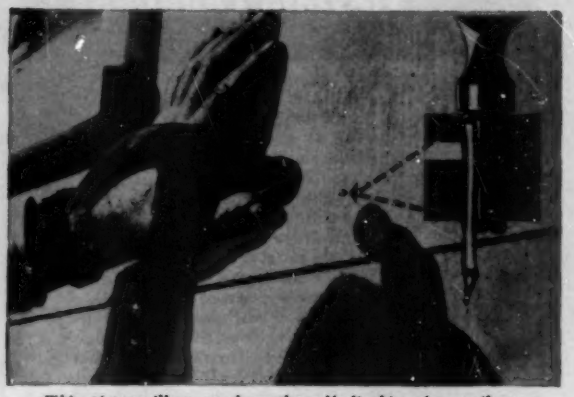

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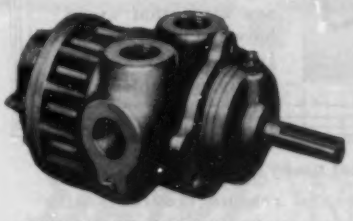
It takes plenty of stamina to stay in this league...

THAT'S WHY **ROPER PUMPS** ARE USED ON MODEL B **TOURNAPULLS***



"B" Tournapulls hauled 77,000 cu. yds. of gravel on this levee building project in California. The Roper 17F Pump is an important part of this LeTourneau earthmover.

Rugged Roper Pumps are an integral part of Tournapull's* Transmission lubricating system. These pumps carry essential oil to vital transmission bearings. The main oil line has trunks extending to various bearing positions . . . the Roper 17F3 Pump is driven off the compound shaft gear and is turning continuously in this application.

This is one of many examples of Roper Pumps proving their stamina and efficiency through grueling hours of tough-run operation. Small wonder Ropers are depended upon. Features such as helical pumping gears running in axial hydraulic balance, flange-type bronze bearings, deep packing box with split rings and easily removable split gland, and self-lubrication of all bearings and trunnions add to long service life in a wide range of heavy-duty applications.

Like LeTourneau, you will find the Roper F Series a sound investment for installations requiring a pump for pressures up to 300 P.S.I. in sizes from 1 to 300 G.P.M.

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MOLDED PLASTICS PRODUCTS—MOLDED RESISTORS

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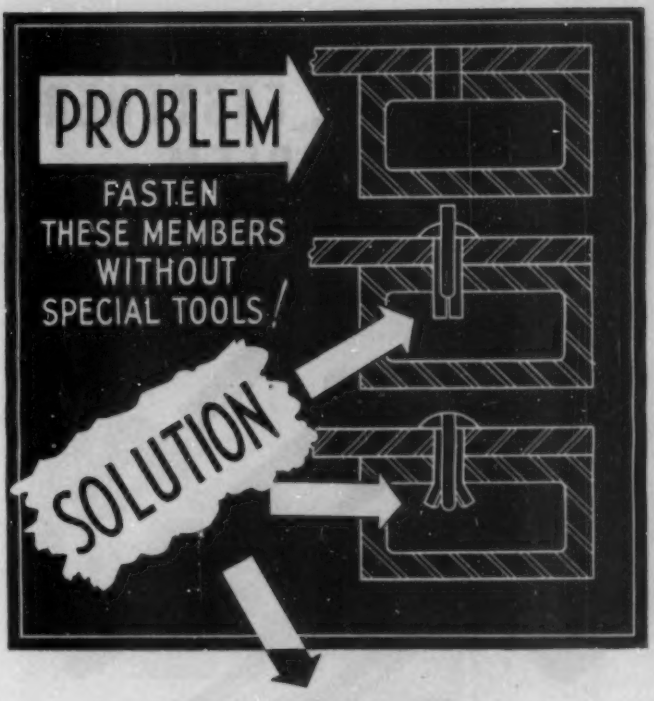

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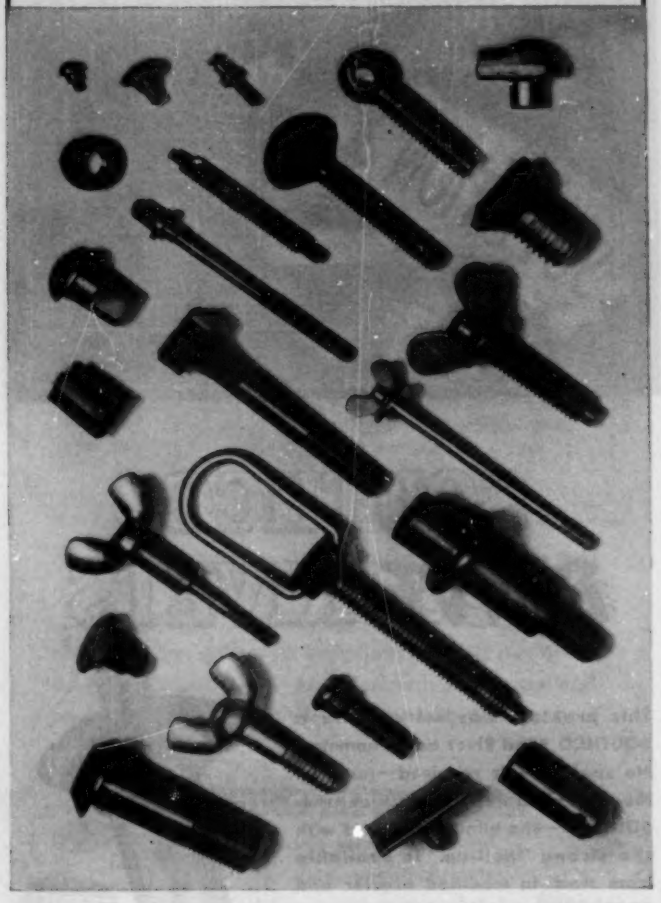

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THE NATIONAL SCREW & MFG. COMPANY...CLEVELAND 4, OHIO

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To Improve Bushings, Bearings, Cylinders For Smoother Running, Longer Life of Products

Sunnen Honed bushings, bearings, and cylinders are *straight and round.* No bellmouth, no taper—no high spots or ridges—and no "washout" at ports and grooves. Sunnen Honing produces *full bearing surface* with any desired finish to 2 micro-inches R.M.S. Leading St. Louis industries, as well as those in your area, use it to improve vital machine parts—to step up performance and increase life of their products—to furnish their sales forces with convincing sales features.

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Sunnen Honing virtually eliminates chucking, fixtures and set-up time . . . maintains accurate alignment between in-line bushings . . . eliminates selective fitting . . . speeds assembly . . . reduces rejects . . . salvages valuable parts . . . hones metals, ceramics and glass . . . is guaranteed accurate to within .0001". On some production jobs tolerance is held to within *25 millionths of an inch.*

Stationary equipment hones diameters from .120" to 5.5" (portable equipment range: .185" to 14.5"). Hones open and blind holes, and holes with keyways, ports and lands.

You can have better products at lower cost . . . avoid production headaches . . . by specifying Sunnen Honing at the design stage. Investigate now!

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Company.....

Address.....

City.....

State.....

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Henry Lackman, *Foreman*
Wagner Electric Corp.

Hydraulic brake wheel cylinder
Material = Cast iron
Hole Diameter = 1.125"
Length = 3.250"
Tolerance = .001"
Finish = 20 micro-inches
Stock Removal = .001"
Production = 1 per minute

Assures Longer Service Life

John Mehefer, *Plant Superintendent*
Lincoln Engineering Company

Grease pump barrel
Material = Steel tubing
Hole Diameter = 1.623"
Length = 5" • Tolerance = .001"
Finish = 8 micro-inches
Stock removal = up to .010"
Production = 10 per hour

Removes Distortion After Hardening

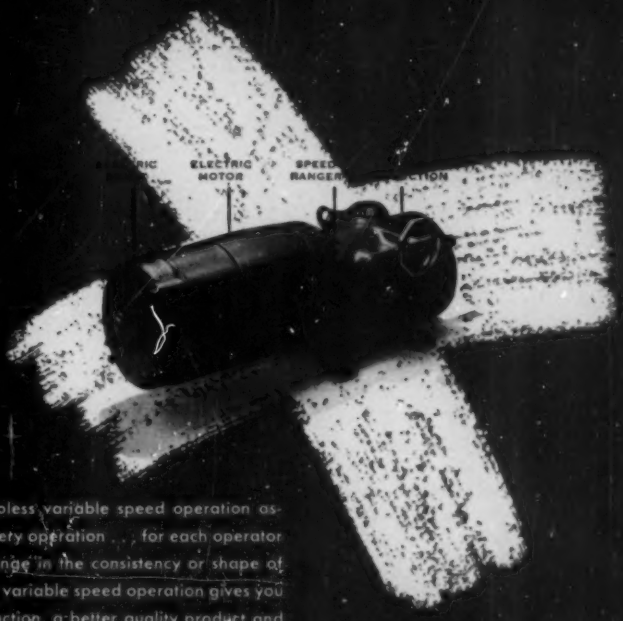
A. J. Stamm, *Plant Superintendent*
Measuregraph Corporation

Pump engine tappet with tandem holes
Material = 1020 carburized steel
Hardness = Rockwell 60-63 "C"
Hole Diameter = .625"
Length = 1 5/16" (each hole)
Tolerance = .00025"
Finish = 10 micro-inches
Stock removal = .0005" to .001"
Production = 1 per minute

Produces Accurate Parts—Economically

Wm. Barry, *Foreman*
Lewis Invisible Stitch Company

Sewing machine "looper carrier"
Material = Drop forging
Hardness = Rockwell 61 "C"
Hole Diameter = .250"
Length = 1"
Tolerance = .0001"
Finish = 15 micro-inches
Stock removal = .0005" to .0007"
Production = 40 per hour



On thousands of applications, stepless variable speed operation assures exactly the right speed for every operation . . . for each operator . . . the right speeds for each change in the consistency or shape of the material being processed. Such variable speed operation gives you plus value in higher rates of production, a better quality product and more efficient performance of your equipment and your operators.

Master Speedrangers provide this infinitely variable speed in compact, all-metal, mechanical variable speed units in a wide range of types and in sizes up to 5 horsepower.

PLUS VALUE

For example, see how the Speedranger on this machine incorporates an electric motor, a variable speed unit, a gear reduction unit and an electric brake . . . all standard Master units that easily combine into a compact, integral power package. This provides exactly the RIGHT horsepower, the RIGHT range of speed, the RIGHT features, in a unit that you can use RIGHT where you want it.

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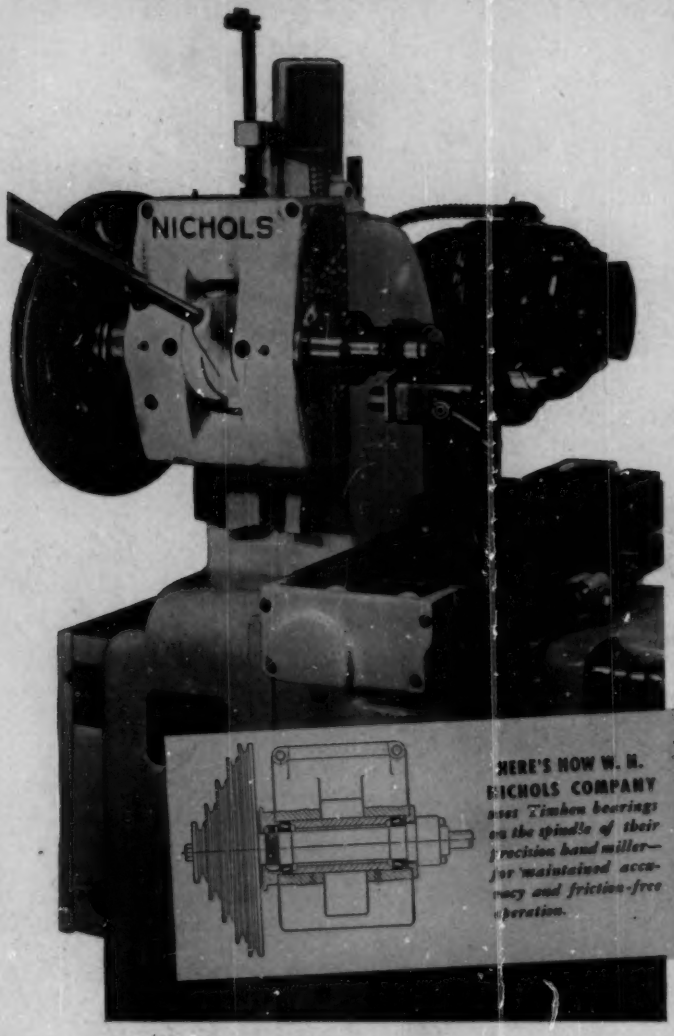
THE MASTER ELECTRIC COMPANY · DAYTON 1, OHIO

MASTER SPEEDRANGERS

Hand miller that "uses its head" has spindle mounted on TIMKEN® bearings



HERE'S HOW W. H. NICHOLS COMPANY uses Timken bearings on the spindle of their precision hand miller—for maintained accuracy and friction-free operation.

THIS Nichols hand miller "uses its head" to give unusual versatility as well as high standards of precision. The counter-balanced head slides up and down enabling the tool to be brought to the work for extra flexibility in many milling operations.

To insure smooth, accurate cutting and freedom from chatter, the spindle is mounted on Timken® tapered roller bearings.

Timken bearings help to hold the spindle rigid—keep it revolving accurately under all loads. The line contact between the rolls and races gives maximum spindle support. There's less chance of deflection. Tapered construction enables Timken bearings to carry both radial and thrust loads in any combination and permits accurate pre-loading. End-movement is controlled within the close limits required for precision machining.

Because of their true rolling motion and the finishing of rolls and races to incredible smoothness, Timken bearings practically eliminate friction. And since they're made of the finest steel ever developed for tapered roller bearings—Timken fine alloy steel—Timken bearings normally last the life of the machine.

For top performance, be sure you have Timken bearings in all the machine tools you build or buy. Look for the trade-mark "Timken" on the bearings. The Timken Roller Bearing Company, Canton 6, O. Cable address: "TIMROSCO".

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What an opportunity for manufacturers of machines where extreme accuracy is essential! Available in standard single row types, up to 10" O.D. Write for further information.

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